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COMMUNITY INVOLVEMENT IN THE ASSESSMENT OF THE HEALTH OF SELECTED REMNANTS IN SOUTH-WESTERN AUSTRALIA.

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CONTENTS

PART I: GENERAL INTRODUCTION

Australian landscapes have provided scientists with a plethora of evolutionary insights and ecological challenges. In Western Australia, a unique environmental history has resulted in a biotic richness in the south-west affording it recognition as one of 25 global biodiversity hotspots (Myers *et al.* 2000). The lack of glaciation or marine inundation for 250 million years, and the climatic turmoil over the last 10 million years, have converted a landscape predominantly covered in rainforest with some patches of sclerophyll, to one covered by sclerophyll with no rainforest remaining (Hopper 1992). Lengthy periods of time have allowed the development of faunal and floral endemism within these landscapes. A remarkable level of species turnover across the landscapes is also apparent within the south-west, where ecosystem types range from closed

forests on the southern fringes, to shrublands and open woodlands as one progresses east to the drier interior (Beard 1990, Hobbs 1992). While such ecosystems may have been resilient to perturbations encountered in their evolutionary history, they are unusually vulnerable to newly introduced perturbations, such as the impacts of human activity (Vitousek *et al.* 1997, Rapport and Whitford 1999). European settlement in the South–west spans a mere 176 years. The anthropomorphic changes and degradation of these extremely diverse landscapes are now providing ecologists and land managers with immense challenges in terms of recognition and restoration.

Extensive areas of the south-west of Western Australia have been cleared for agriculture, mining and urbanisation. Although the importance of revegetation of such areas is now recognised and practiced, as little as 3% of some types of woodlands remain in the wheatbelt (Hobbs 1999). Saffer *et al.* (2000) examined and compared pollination and floral productivity in areas of remnant vegetation and revegetation in the South-west of Western Australia. In that study, results indicated a greater floral productivity in areas of revegetation than in remnant patches and that birds, particularly generalist honeyeaters, were more abundant in revegetated areas than in remnant patches. Given these results, the health of remnant patches was questioned. Furthermore, when the established trees eventually die, is there sufficient regenerative potential to sustain the remaining remnant vegetation? It became apparent that a means of assessing the health of remnant vegetation was required, which would also incorporate indicators for restoration. The assessment of the health of these remnant patches, together with indications for restoration, is a vital step in their sustainability and restoration.

One perspective of environmental quality evaluation or ecosystem function analysis that has gained popularity recently is the concept of "ecosystem health", and the extension of health to describe symptoms, diagnose dysfunctions and prescribe treatment within ecosystems (Bertollo 1998, Rapport *et al.* 1998). Central to this theory is extending the concept of health from its traditional domain of application at the individual and population levels to that of ecosystems (Rapport *et al.* 1999). This extension of health is a response to the evidence that human-associated ecosystems have become highly dysfunctional (Rapport *et al.* 1998). Rapport *et al.* (1998) recognised the need for methods of identifying dysfunctions within ecosystems and evaluating causes and potential solutions.

Definitions of ecosystem health have been closely allied with the concepts of stress ecology, which define health in terms of system vigour, organization and resilience (Rapport *et al.* 1998). Vigour is measured in terms of activity, metabolism or primary productivity, organization is measured in terms of the diversity and number of interactions between system components and resilience is measured in terms of a system's capacity to maintain structure and function in the presence of stress. These indicators were used to monitor the health of selected patches of remnant vegetation in the South-west of Western Australia. Vigour was

assessed by determining vegetative growth and recruitment. Organization was assessed by measuring the diversity of the biotic component, while disturbance, degradation and seed assessment tested the resilience of the system.

Many patches of remnant vegetation are isolated within agricultural farmlands (Yates and Hobbs 1997). Members of the rural community have more exposure to patches of remnant vegetation in remote areas and can provide the necessary manpower to monitor vegetation in such areas. Thus, a means of assessment must be user-friendly for farmers and professionals alike, able to be used in rural and urban settings and incorporate critical information to ensure a valid assessment.

This current report presents the results of a project undertaken by the Western Australian Naturalists' Club and funded by the Western Australian Lotteries Commission's Gordon Reid Foundation for Conservation in which the 'health' of selected reserves of remnant vegetation was determined and a table of ecosystem health assessment developed.

Two reserves of remnant vegetation, sufficiently different in terms of location, ecology and management history were selected for this study. Local community groups were willing to participate in the monitoring and assessment of ecosystem health, as well as assist with trials and refinement of a table of assessment.

STUDY SITES

RESERVE 1 – GOOMALLING

- Reserve 1562, hereafter referred to as Goomalling, is located within the wheatbelt approximately 1km east of Goomalling (Figure 1) at 31°16'S, 116°47'E.
- Goomalling falls within the Transitional Rainfall Zone defined by Hopper (1979) (Figure 1). Average annual rainfall is approximately 370 mm and rain falls on a mean of 82.5 days per year (Bureau of Meteorology, Perth).
- The reserve is 120 hectares in size and is surrounded by agricultural land (wheat fields) to the north and north-east, and a disturbed woodland to the west, including a disused rifle range (Figure 2). A major road forms the remaining boundary with wheat fields abutting the road. A cemetery is situated within the reserve and a railway line runs though it from north to south.
- The current status of this reserve is Class C: Travellers and Stock.
- The vegetation consists of a mixed eucalypt woodland with York Gum (*Eucalyptus loxophleba* subsp. *loxophleba*), Gimlet (*E. salubris*), Salmon Gum (*E. salmonophloia*) and Red Morrel (*E. longicornis*) dominating and an open understorey.

Members of the Toodyay Naturalists' Club were willing to conduct observations in the reserve. Toodyay is situated approximately 45 km west of Goomalling. Goomalling does not have a naturalists club and some members of the Toodyay Naturalists Club were resident within the Shire of Goomalling.

RESERVE 2 – FRANKLANDIA

- Franklandia Reserve, No. A1167,

hereafter referred to as Franklandia, is located near the west coast of Western Australia approximately 14 km south, south-east of Bunbury (Figure 1) at 33°25'S, 115°42'E.

- Franklandia is situated within the High Rainfall Zone (Hopper 1979; Figure 1) and average annual rainfall is approximately 900 mm. Rain falls on a mean of 122.3 days per year (Bureau of Meteorology, Perth).
- The reserve is 19.56 hectares in size. It is officially classified as Class A : Parklands and is surrounded by agricultural land (Figure 3). Land adjacent to the north was not cleared but was stocked with cattle. Land to the west was cleared, not stocked and was regenerating while land to the south was cleared and stocked with cattle. Infrequent, short-lived incursions of cattle into the reserve occurred prior to 1995. A major road runs along the eastern boundary.
- Jarrah (*Eucalyptus marginata*) and Banksias dominated the vegetation with a moderately to highly dense understorey.
- The reserve is managed by the Department of Land Administration (DOLA), the Department of

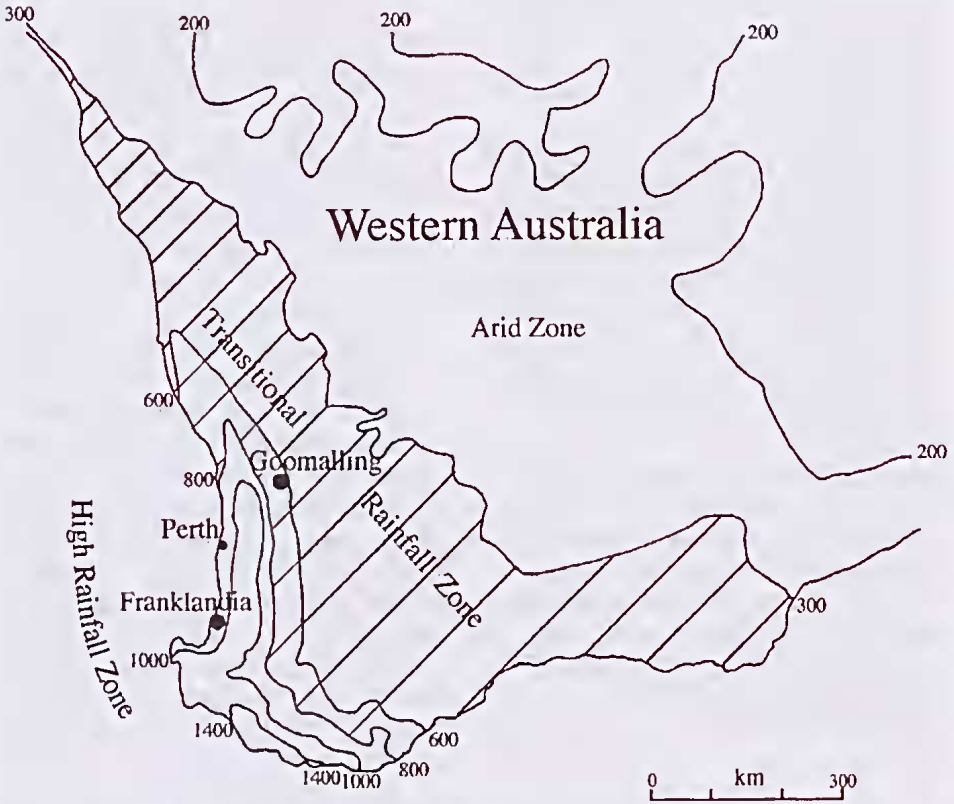

Figure 1. Location of Goomalling and Franklandia Reserves and distribution of major annual rainfall isoheyts (mm) and rainfall zones in south-western Australia.

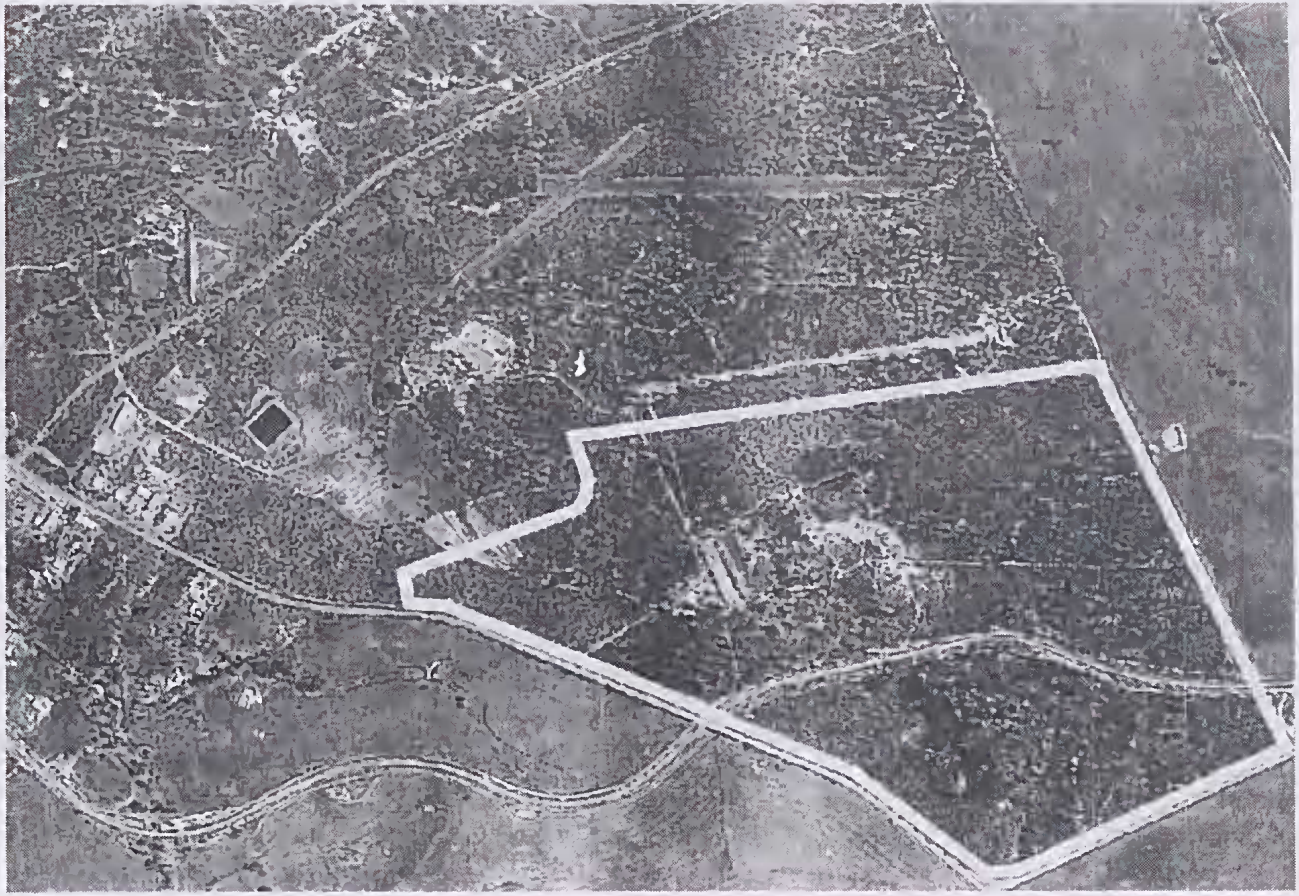

Figure 2. Aerial photograph showing Reserve 1562.

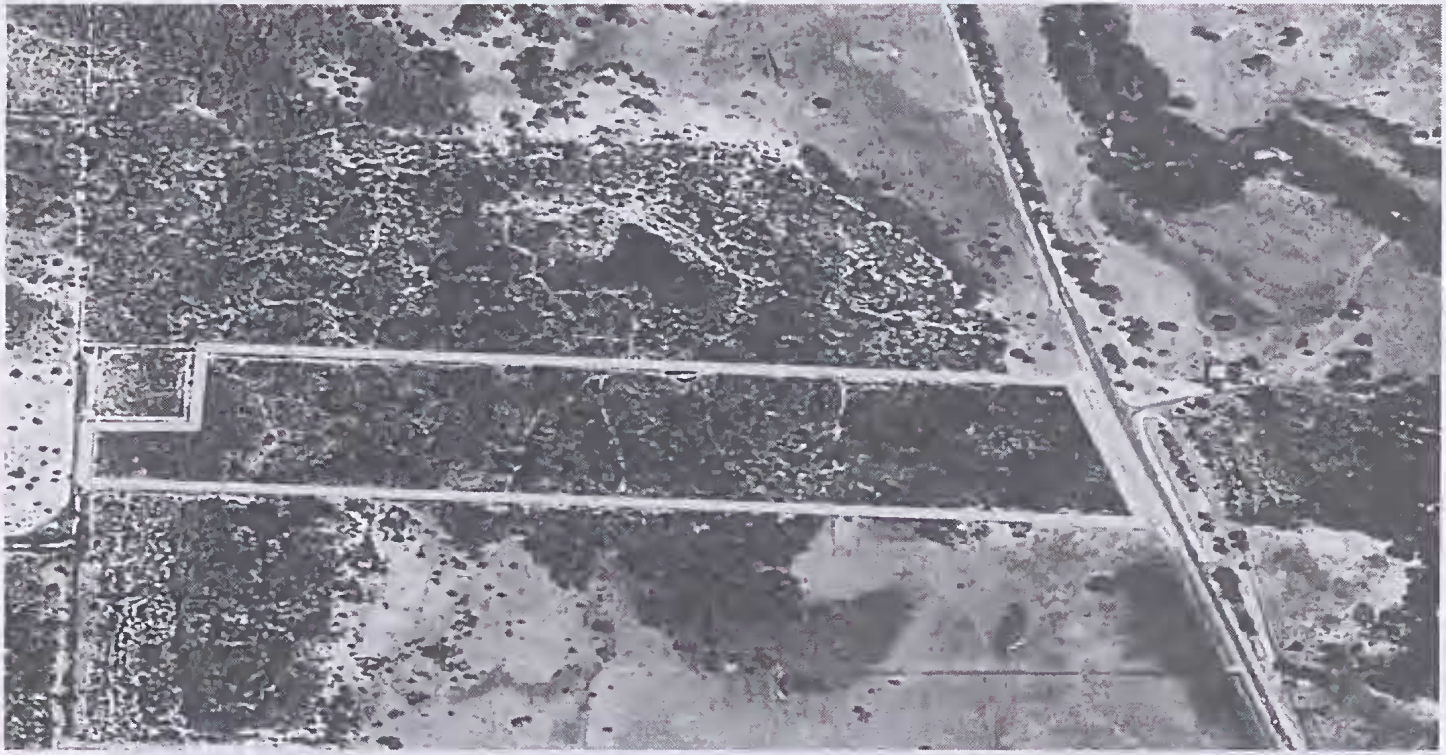

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Figure 3. Aerial photograph showing Franklandia Reserve.

Conservation and Land Management (CALM) and, in 1995 members of the Bunbury Naturalists' Club became official caretakers. Members of the Bunbury Naturalists Club were willing to participate in the Project.

MONITORING SITES

Within each reserve, four sites, representative of the dominant vegetation, were selected for intensive monitoring. For Franklandia, eight sites had been prescribed previously within the reserve: four of these sites were selected for this study. In each reserve, sites were measured to 10m x 10m and marked with stakes for the duration of the study.

METHODOLOGY

MONITORING ROUTINE

A total of 12 field trips was made to each reserve between October 1999 and July 2001: eight trips were made to each reserve during the first year (October 1999 – September 2000) and four trips were made to each reserve during the second year (October 2000 – September 2001). Monitoring during the first year was planned to coincide with the beginning and end of each climatic season and, during the second year, each trip was planned to coincide with the middle of each climatic season. This temporal pattern ensured that all climatic periods were included so that migratory birds had an equal chance of being observed, and plant species that flowered during different seasons were included. Similarly, seasonal variation in mammal and invertebrate abundance was sampled.

For the first field trip, four volunteers attended four consecutive mornings to conduct the monitoring. Thereafter, this changed to eight volunteers on two consecutive mornings. At each reserve, on each of two mornings during each field trip, four pairs of volunteers rotated through the four sites, spending 20 minutes at each site. A qualified biologist also rotated through the four sites, spending 20 minutes at each site, either on the same mornings as the volunteers, or on mornings immediately before or after the volunteer sessions. The order in which the sites were visited by the biologist was alternated to avoid time-of-day bias. Monitoring commenced each morning as soon after sunrise as possible.

BIRDS

At each site, the numbers of birds seen and heard within a 50m radius during a 20-minute period were recorded. Every attempt was made not to record the same bird twice. Nomenclature follows Christidis and Boles (1994).

INVERTEBRATES

At each site, all invertebrates sighted, both on substrates and in flight, during the 20-minute period were recorded. Where individual invertebrates were too difficult or numerous to count, for example a trail of ants, an arbitrary figure of 10 individuals was recorded.

Nomenclature follows "The Insects of Australia" (CSIRO 1970).

The details and results of this study are presented in this publication as a progression of three further parts:

- Part II assesses the reliability of data collected by volunteers. This

establishes that volunteer surveys can be a reliable indicator of species richness and abundance.

- Part III details the results of intensive monitoring of the two reserves over a two-year period.
- Part IV in which a critical assessment of the intensive monitoring was used to design and refine a means of evaluating ecosystem health and suggest indicators for restoration. Examples of ecosystem health assessment of the two study reserves using the table are provided.

In a separate paper in this volume, the results of a satellite study of the soil seed-banks of the two reserves are presented (Saffer *et al.* 2002).

ACKNOWLEDGEMENTS

I would like to thank the Western Australian Naturalists' Club for supporting this project, the Western Australian Lotteries Commission's Gordon Reid Foundation for Conservation for providing the funding and Kings Park and Botanic Gardens for use of facilities. Thanks also to members of the Steering Committee: John Dell and Roz Hart representing the Western Australian Naturalists' Club, and Steve Hopper, Ray Wills and Ian McLean from Kings Park and Botanic Gardens. Thanks to Gordon Elliott of the Western Australian Naturalists Club for managing the finances. Many individuals participated in the project and are thanked in each part appropriately.

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PART II: VOLUNTEER SURVEYS AS A RELIABLE INDICATOR OF SPECIES RICHNESS AND ABUNDANCE

INTRODUCTION

Government departments and funding bodies often require lengthy, detailed, scientific reports produced by trained professionals on, for example, the ecological status of a catchment area, a prescribed landscape or a contained patch of remnant vegetation before prioritizing limited funds and assisting in land rehabilitation (Chipenuik 1996).

In Western Australia, the extent of landscape degradation and the need for health assessment and restoration initiatives is well recognized. However, the personnel and time required to assess ecosystem health, plan, execute and monitor restoration, extends beyond the financial scope of any one government department. For some time, there has been a growing awareness within local communities of the debilitation of ecosystems and the progressive degradation of vast tracts of land. Concomitantly, there has been an ever increasing movement within communities to do something about these issues (Bradby 1997, Wills and Hobbs 1998). As groups within communities have been established to attend to selected issues of environmental assessment and repair, the validity of their assessment has generally been assumed to be reliable.

This study used community groups in the assessment of the health of two selected remnants. As part of this study, volunteers and a professionally qualified biologist (the present author) monitored the numbers and species of birds heard and seen and the numbers and orders of invertebrates seen over time. This provided an opportunity to assess the reliability of data collected by volunteers by comparing their results to those of the qualified biologist.

METHODS

VOLUNTEER EFFORT

A total of 12 field trips was made to each reserve between October 1999 and July 2001 (for details on reserves see Part I).

Initially, four volunteers were requested to be present on four consecutive mornings to conduct the monitoring. After the first field trip, this changed to a request for eight volunteers on two consecutive mornings. The reasons for this change were two-fold. Firstly, in spite of the enthusiasm of members of the naturalist clubs and other interested individuals, it proved unrealistic to get four volunteers to be present on four consecutive mornings. Secondly, the level of skills of four individuals on any one of the four mornings proved too different to assure meaningful, comparative results. A "buddy" system was subsequently introduced in which eight volunteers were present on only two mornings, and two individuals with different levels of field identification skills were partnered. These partnerships enabled those with greater skills in field identification of one or more biotic elements to educate those with lesser or different skills.

While some volunteers were highly

skilled in identification, none had received any official training. The professionally qualified biologist had completed a doctorate that included field identification of both birds and invertebrates.

MONITORING ROUTINE

Monitoring was followed as described in Part 1. Each pair of volunteers was provided with a folder containing the appropriate paperwork, which included all categories to be recorded. A point-form reminder of the requirements was also pasted onto the folder.

BIRDS

In addition to recording the numbers of birds seen and heard at each site, as described in Part 1, volunteers were asked to record the activity of each bird. If the bird was using a plant in any way (for example, perching, foraging, nesting), the identification of the plant was also recorded. The biologist recorded the same details as the volunteers.

INVERTEBRATES

Volunteers and the biologist recorded invertebrates as described in Part 1. In order to assess volunteers' responses to requests for additional observations, and to add information to the data bank, each pair of volunteers was asked to remain at the final site for an additional 20 minutes where they were to conduct an intensive invertebrate search including under logs, in leaf litter, on foliage etc.

ANALYSIS

Multivariate analysis of variance was used to compare differences in observations recorded, with the reserves and (volunteer and qualified) observers as independent factors and the sampling method and occasions (field trips), the dependent variables. For the birds, the dependent variables included the number of birds seen, the number of birds heard, the number of bird species seen and the number of bird species heard, and, for the invertebrates, the number of individual invertebrates and the number of invertebrate orders were used. The test statistic was Rao's R (Tabachnick and Fidell 1996). As sampling intensity differed between field trips in terms of the numbers of volunteers and minutes of observations, comparisons were made in all categories per person minutes.

QUESTIONNAIRE

Each volunteer was asked to fill out a form (Appendix 1) on their first morning of monitoring in which they rated their skills of identification. All volunteers who attended monitoring sessions for a minimum of three mornings over the two years of monitoring were asked to fill out a repeat form after all monitoring sessions were completed. The initial and final forms for each of these volunteers were compared to assess if they felt that their skills of identification had changed over the two-year monitoring period.

RESULTS

VOLUNTEER EFFORT

Volunteers attended 26 mornings during 12 field trips to each reserve between October 1999 and July 2001. During the first field trip, four mornings were

attended by volunteers, and during all subsequent trips, volunteers were present for only two mornings. Collectively, 32 individuals visited Goomalling 176 times, totaling 234.7 hours of observations. At Franklandia, 31 individuals made 169 visits totaling 226.7 hours of observations.

Volunteer attendance was irregular (Table 1). As the optimal number of volunteers was eight on each morning, eight or more individuals were present on only 39% of mornings at Goomalling and 27% of mornings at Franklandia.

BIRDS

The total number of birds seen or heard, or the number of bird species seen or heard did not differ between reserves (Table 2). Observers did not differ significantly in the total number of birds seen, but the biologist heard more birds, saw more bird species and heard more bird species than the volunteers (Table 2, Figures 1 – 4). However, the relative

Table 1. Volunteer frequency at monitoring sessions at Goomalling and Franklandia.

	Number of persons present	Number of sessions	Percentage of total visits
Goomalling	9	3	12%
	8	7	27%
	7	5	19%
	6	5	19%
	4	5	19%
	3	1	4%
Franklandia	9	1	4%
	8	6	23%
	7	9	34%
	6	7	27%
	5	1	4%
	4	2	8%

Table 2. Results of MANOVA for the dependent variables birds seen, birds heard, bird species seen and bird species heard, classified by reserve and observer.

	Birds seen			Birds heard			Bird species seen			Bird species heard		
	Rao's R	df	P	Rao's R	df	P	Rao's R	df	P	Rao's R	df	P
Reserve	5.8	1,12	0.314	71.5	1,12	0.092	26.4	1,12	0.151	40.1	1,12	0.123
Observer	10.7	1,12	0.235	42325.6	1,12	0.004	6668.0	1,12	0.010	1026.2	1,12	0.024
Reserve x Observe	0.3	1,12	0.904	9.2	1,12	0.253	4.7	1,12	0.346	12.3	1,12	0.220

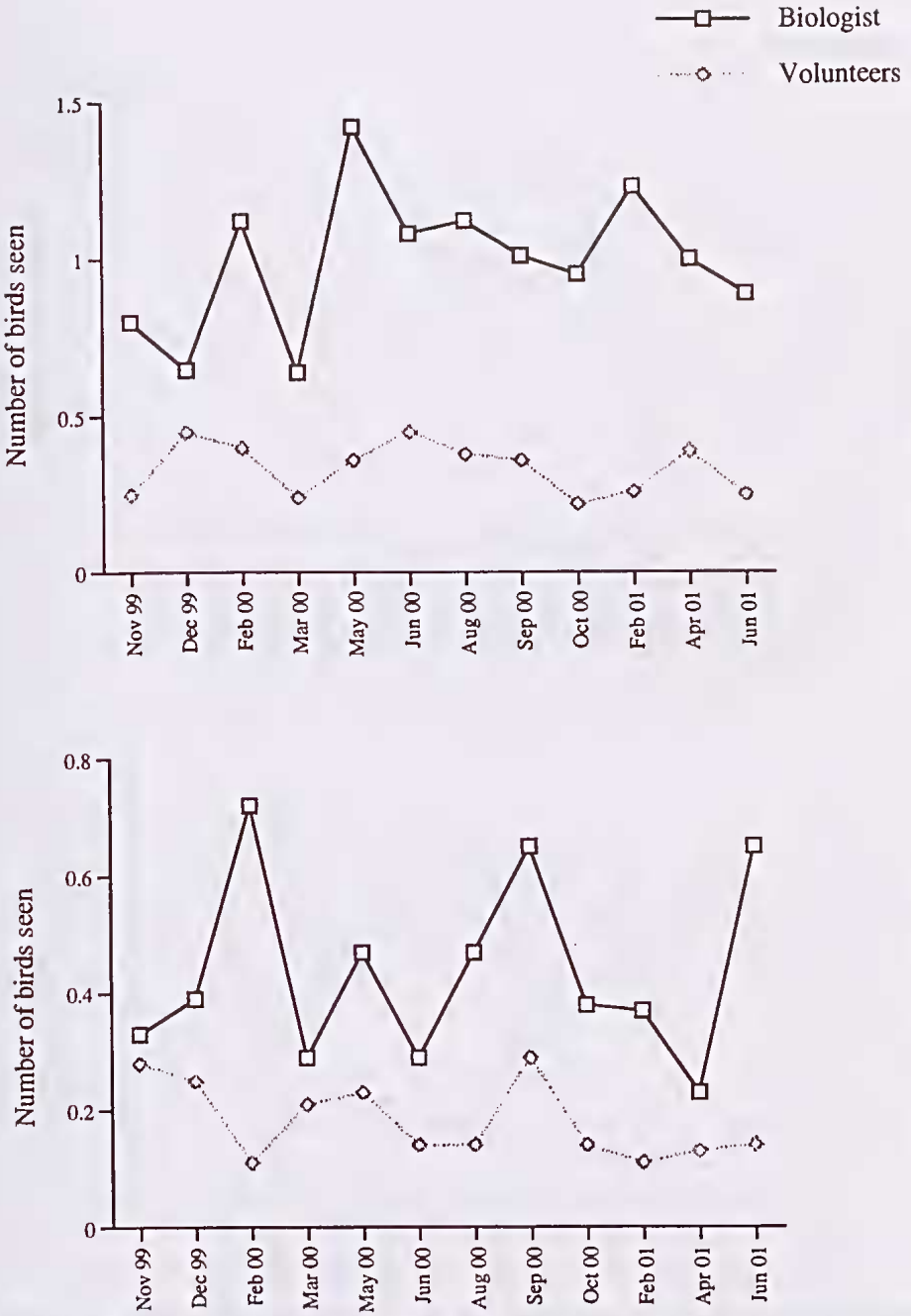

Figure 1. Number of individual birds seen by a biologist and volunteers at Goomalling (upper graph) and Franklandia (lower graph). Data presented as mean number of birds seen per person/minute of observations per field trip.

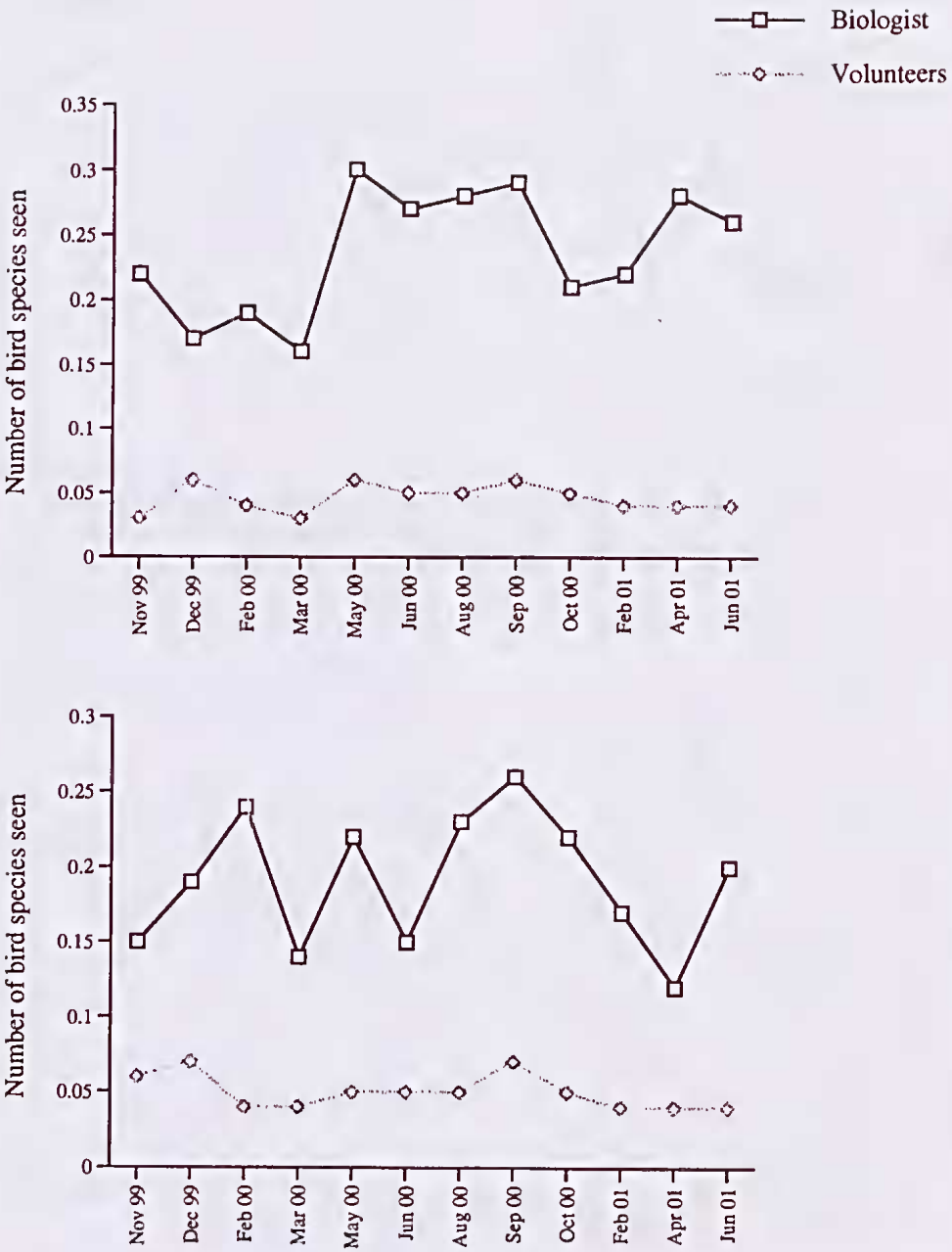

Figure 2. Number of bird species seen by a biologist and volunteers at Goomalling (upper graph) and Franklandia (lower graph). Data presented as mean number of bird species seen per person/minute of observations per field trip.

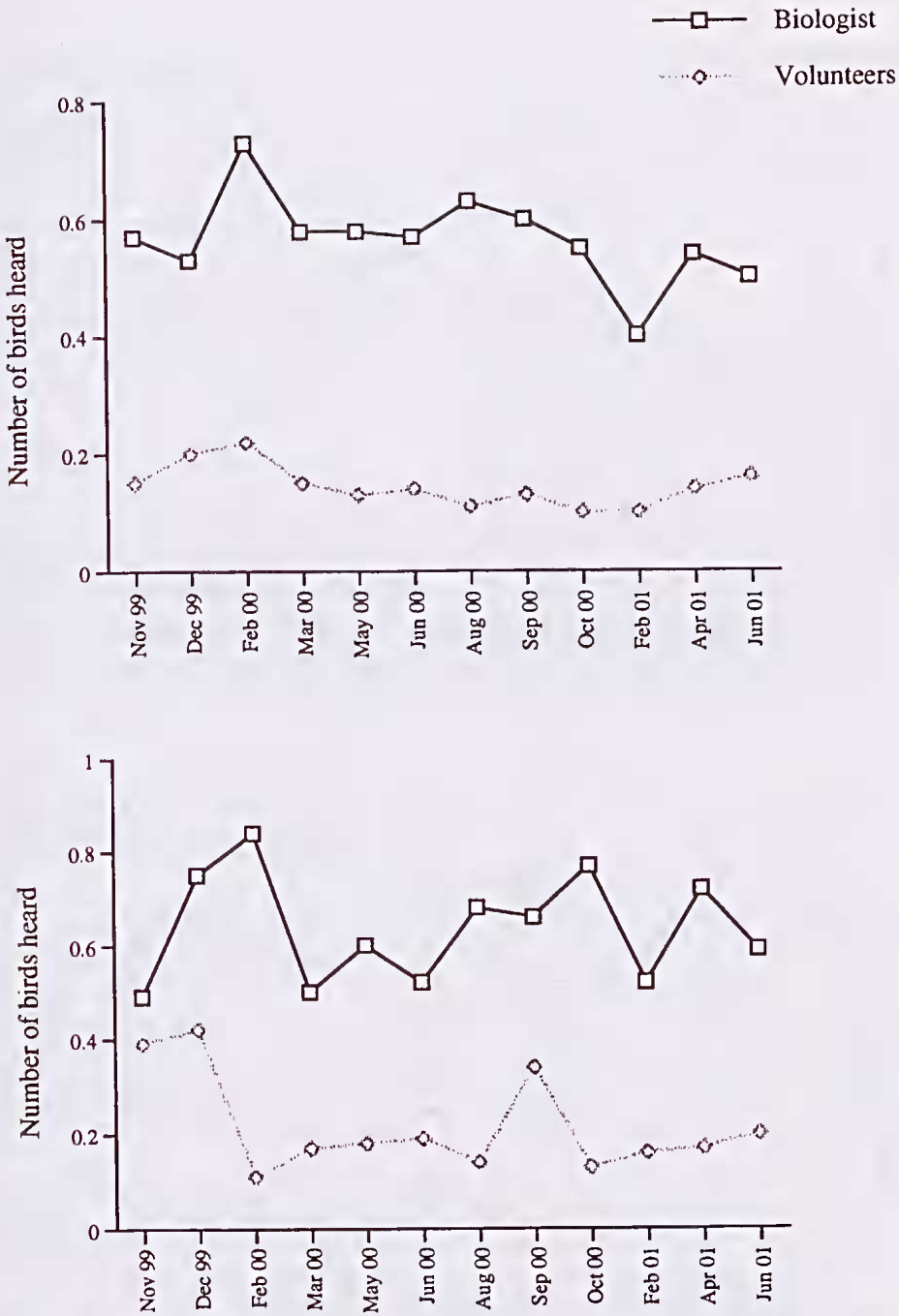

Figure 3. Number of individual birds heard by a biologist and volunteers at Goomalling (upper graph) and Franklandia (lower graph). Data presented as mean number of birds heard per person/ minute of observations per field trip.

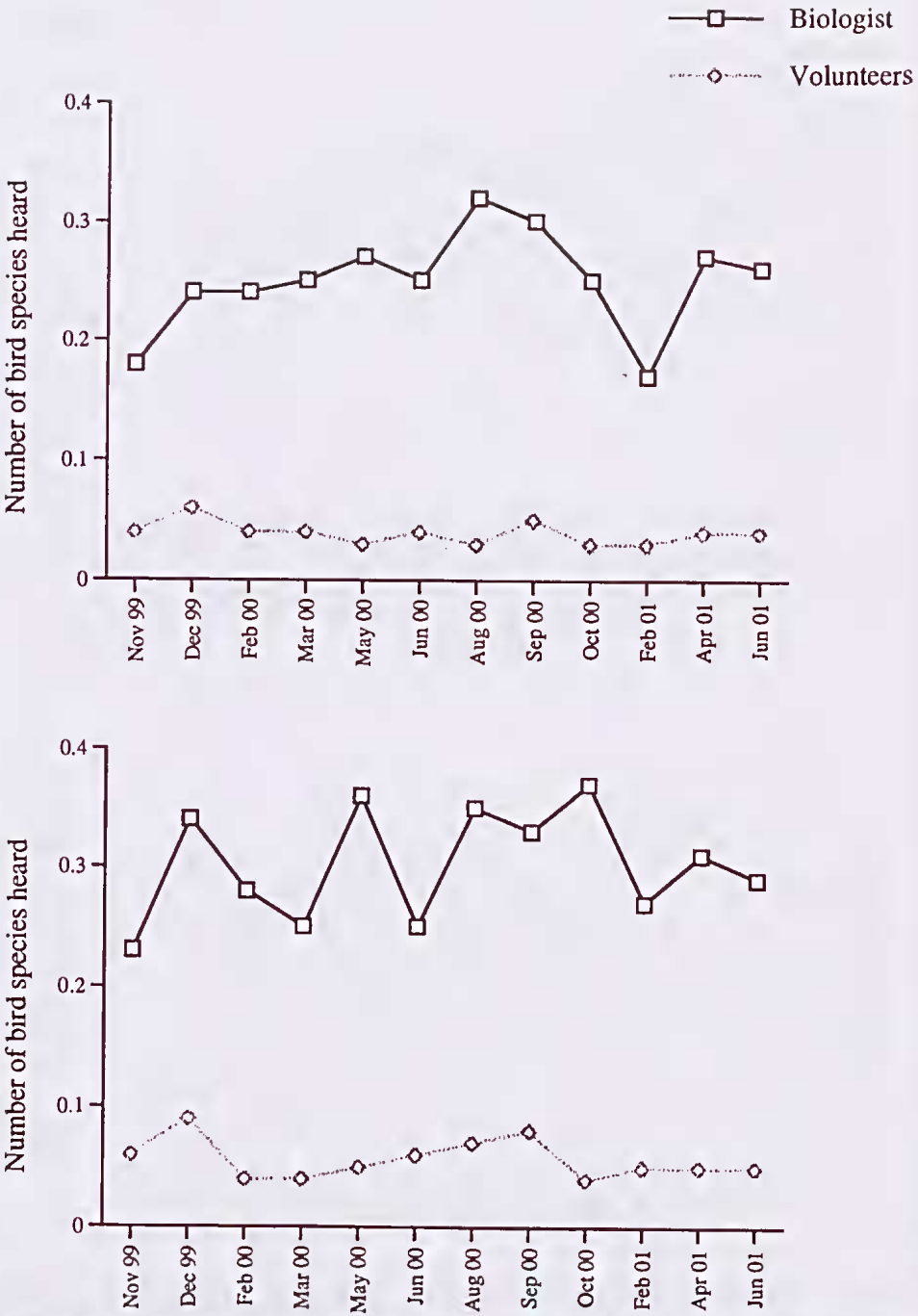

Figure 4. Number of bird species heard by a biologist and volunteers at Goomalling (upper graph) and Franklandia (lower graph). Data presented as mean number of bird species heard per person/minute of observations per field trip.

ability of the biologist and volunteers did not differ across reserves.

In response to requests to record activities of birds seen, and the substrates upon which they were active, volunteers at Goomalling completed 87.8% of entries (Table 3), compared to 99.7% by the biologist. At Franklandia, volunteers completed these details in only 64.2% of entries, compared to 99.3% for the biologist.

INVERTEBRATES

The number of invertebrates seen and the number of invertebrate orders was similar in both reserves and these numbers did not differ between biologist and volunteers (Table 4, Figures 5, 6).

Of a potential eight additional intense invertebrate searches during each field trip, eight were performed on only 25% of occasions in both reserves, seven were completed during 50% of field trips, with the remaining field trips accounting for six (17%) and four (8%) additional searches.

QUESTIONNAIRE

Nineteen volunteers from Goomalling and 19 from Franklandia attended three or more monitoring sessions over the two-year period and were sent repeat questionnaires after all monitoring sessions were completed. Of these, 84% from Goomalling and 95% from Franklandia returned the questionnaire. Of these, only one individual deemed themselves excellent, and that only at the end of the surveys in two of the four categories. The majority scored fair to poor in all categories (Table 5). Overall,

Table 3. Numbers and percentages of bird activity as recorded by a biologist and volunteers at Goomalling and Franklandia.

	Goomalling		Franklandia	
	Biologist	Volunteers	Biologist	Volunteers
Total number of entries of birds seen	580	1515	448	1296
Percentage flying	54.8%	48.3%	49.8%	36.9%
Percentage not flying	44.8%	39.5%	49.6%	27.3%
Substrate not recorded	0.9%	9.6%	1.3%	0.1%
Activity not recorded	0.2%	0.1%	0.4%	1.1%
Substrate nor activity recorded	0.3%	12.2%	0.7%	35.8%

Table 4. Results of MANOVA for the dependent variables number of individual invertebrates and orders of invertebrates, classified by reserve and observer.

	Number of individual invertebrates			Number of orders of invertebrates		
	Rao's R	df	*P*	Rao's R	df	*P*
Reserve	40.4	1,12	0.122	33.4	1,12	0.135
Observer	164.4	1,12	0.061	149.1	1,12	0.064
Reserve x Observer	51.3	1,12	0.109	35.2	1,12	0.131

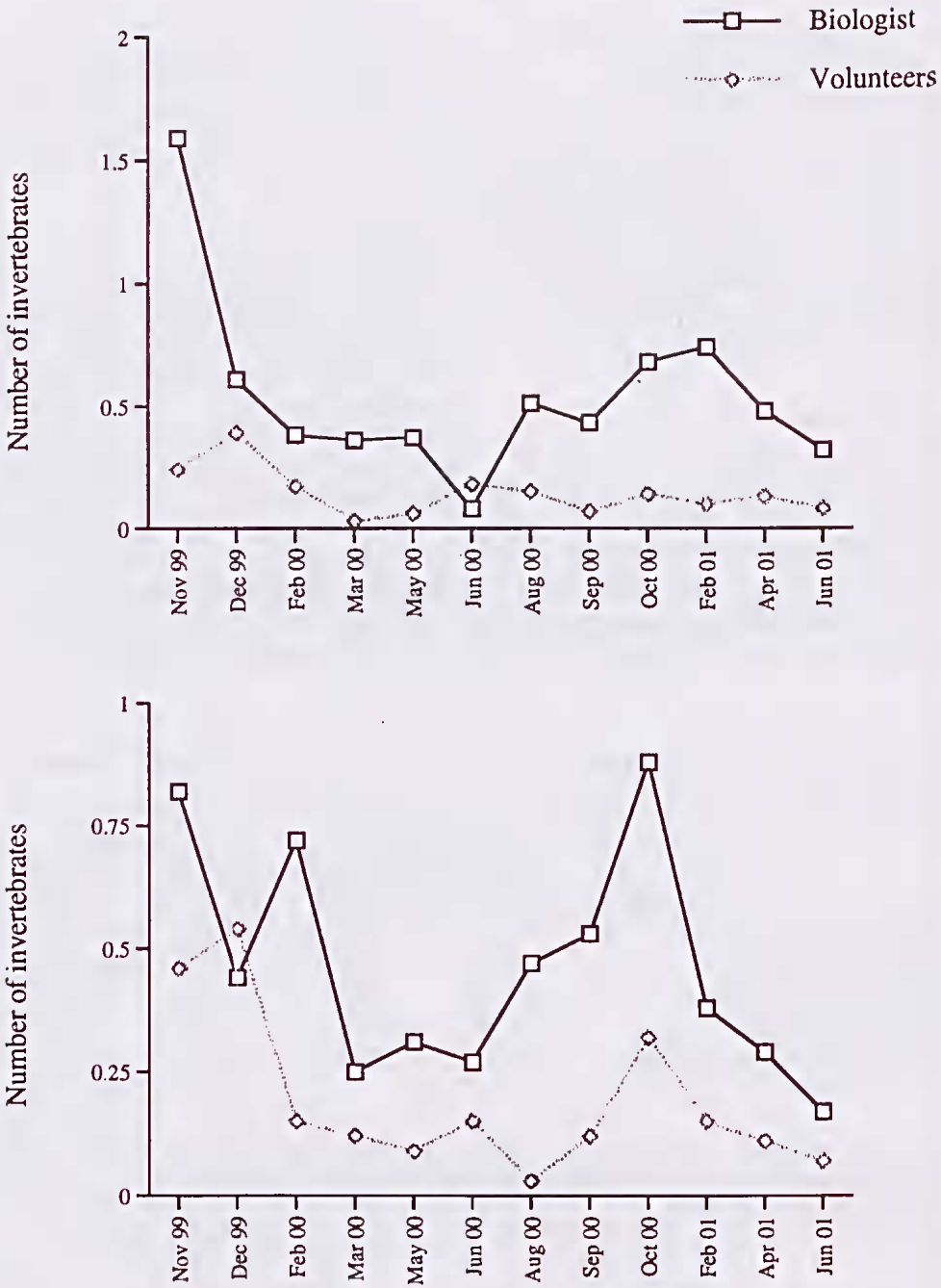

Figure 5. Number of invertebrates seen by a biologist and volunteers at Goomalling (upper graph) and Franklandia (lower graph). Data presented as mean number of invertebrates seen per person/minute of observations per field trip.

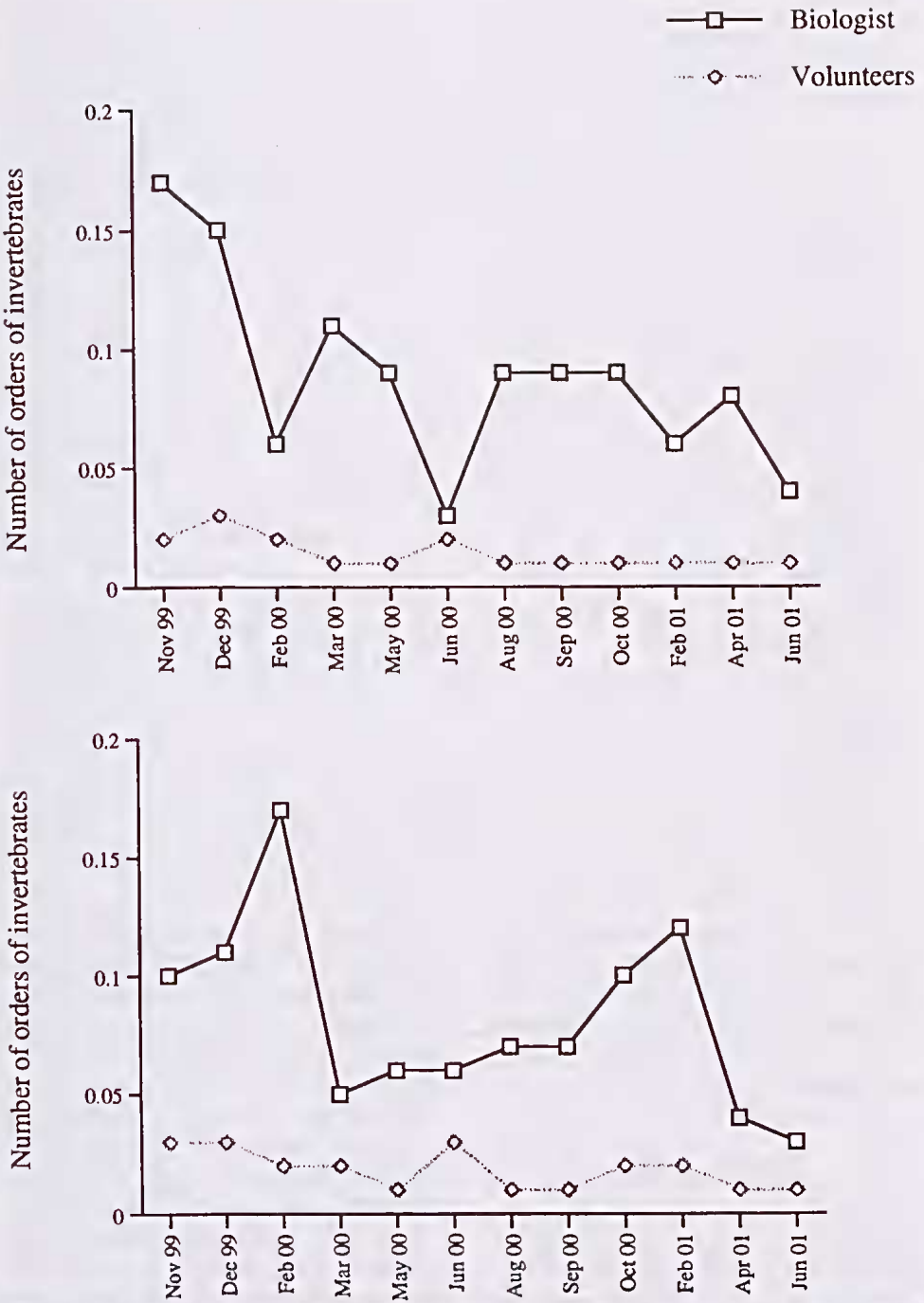

Figure 6. Number of orders of invertebrates seen by a biologist and volunteers at Goomalling (upper graph) and Franklandia (lower graph). Data presented as mean number of orders of invertebrates seen per person/minute of observations per field trip.

Table 5. Results of questionnaires submitted by volunteers at the beginning and end of the monitoring sessions at Goomalling and Franklandia. The number of scores in each category is followed by percent change.

	Birds		Invertebrates		Flora			
					common name		scientific name	
	Initial	Repeat	Initial	Repeat	Initial	Repeat	Initial	Repeat
Goomalling								
Excellent	0	0	0	0	0	0	0	0
Good	3	2	4	2	4	6	2	4
Fair	4	9	6	8	8	7	5	4
Poor	9	5	6	6	4	3	9	7
Franklandia								
Excellent	0	1	0	0	0	1	0	0
Good	7	7	1	2	5	3	4	5
Fair	5	8	6	9	10	14	7	8
Poor	6	2	11	7	3	0	7	6
Percent change								
Goomalling								
Skills								
improved	40%		33%		50%		43%	
remained the same	40%		20%		21%		29%	
deteriorated	20%		47%		29%		28%	
Franklandia								
Skills								
improved	76%		62%		35%		38%	
remained the same	14%		13%		24%		31%	
deteriorated	10%		25%		41%		31%	

identification skills improved at both reserves. Exceptions include invertebrate identification by Goomalling volunteers and knowledge of common names of local flora by Franklandia volunteers.

DISCUSSION

From this study, it is clear that the data collected by volunteers can usefully monitor bird communities and some invertebrate communities, although there are limitations as to what can be achieved by volunteers. In terms of volunteer achievement, the most significant factor was that the biologist and volunteers did not differ in the total number of individual birds seen at both reserves. Therefore, the total number of birds seen is a robust observation that can be used by volunteers to produce similar results to that of biologists, under the same conditions. Significantly, over half of the volunteers felt that their ability to identify birds in the field had improved.

Although the biologist heard significantly more birds, and saw and heard significantly more bird species

than the volunteers, there was no interaction between observer and reserve. In other words, the biologist and the volunteers ranked the reserves similarly with regard to these variables, and followed similar trends over the duration of the surveys. Thus, in surveys where comparisons of sites and trends over time are more important than full species lists, volunteers may contribute useful data.

The similarity in recordings for invertebrates by the biologist and volunteers at Goomalling and Franklandia suggests that for invertebrates, data collected by volunteers were unequivocally reliable indicators of species richness and abundance at these sites.

Collectively, the number of individuals, mornings, visits and the number of hours of observations were similar for both Goomalling and Franklandia. One spokesperson from each of the naturalists clubs was responsible for organizing volunteers. The dates for monitoring were advertised months in advance, yet full attendance (eight individuals on each of two mornings) was achieved in less than half of monitoring occasions. The importance of attendance, in terms of consistency in the numbers of individuals and the monitoring regime, for statistical analysis, was reiterated frequently during the tenure of the project. Furthermore, the suggestion that volunteers record data onto the computer and/or assist in the analysis, was not taken on by any individuals. They were happy to collect the data, but expressed no desire to become involved in the input, analysis or presentation of the material collected.

The low percentage returns of recordings of bird activity and substrate details by volunteers may have been the result of greater concentration on identifying birds, rather than recording the extra details of activity and substrate. Indeed, it appeared that the concentration of volunteers, and the time spent learning and ensuring the correct identity of birds, precluded their recording these additional details. Details of activity and substrate may be critical when selecting plant species for restoration. The appropriate selection of plant species favoured by different bird species for foraging, sheltering and nesting, will ensure a composite vegetation structure that meets the needs of at least the avian element within the ecosystem. Bird identification skills by volunteers improved over time in this study. If bird activity and substrate details are important requisites of future surveys, it would be advantageous to hone bird identification skills of volunteers prior to the commencement of surveys.

Few volunteers conducted the additional, intensive, invertebrate search. As this search was scheduled after the full rotation through the four sites, volunteer enthusiasm may have waned; the volunteers had already spent nearly two hours at the reserve, temperatures had risen and, during the warmer months, soared in the mid to high thirties producing uncomfortable working conditions for some volunteers, and refreshments were beckoning. Therefore, requests made of volunteers, and the associated work load, need to be considered when using volunteer services. A distinction may be noted between volunteers who are asked to attend monitoring sessions at set times and perform field tasks, as against those

who initiate and carry out ecological monitoring at their convenience, and then present data to professionally qualified coordinators, community groups or funding bodies.

Overall, the strengths of volunteer work in this study outweighed the limitations. In the present climate of limited funds and limited trained personnel, results of monitoring by community groups are often used when making important decisions about landcare and directions for restoration. The results of this study, the first of its kind to quantify differences between the results of qualified biologists and volunteers, indicate that volunteer surveys can be a reliable indicator of species richness and abundance, and that decisions for landcare, based on these findings, may be made with confidence.

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Appendix 1. Questionnaire filled in by volunteers at the beginning and end of the two-year monitoring period.

How well do you know your flora and fauna?

Please tick the appropriate box and then give yourself a score out of ten

NAME:

DATE:

	Excellent	Good	Fair	Poor	Out of ten
BIRDS					
INVERTEBRATES					
FLORA:					
Common name					
Scientific name					

Occupation:

Any comments you would like to make:

PART III: ASSESSING ECOSYSTEM HEALTH IN SELECTED REMNANTS USING DATA COLLECTED BY VOLUNTEERS

INTRODUCTION

The well-being and sustainability of patches of remnant vegetation are critical for the maintenance of plant and animal diversity, for selected resources for restoration in terms of seed and cuttings and for the overall health of the local landscape (Hobbs and Saunders 1993, Strawbridge 1999). A comprehensive assessment of the health of remnant areas requires long-term monitoring of all functional units within the ecosystem, and interpreting the results in context of the local landscape. Local knowledge of the area and its history, including its cultural value, must be part of the interpretation in order to fully assess the overall health of the remnant.

The reliability of surveys conducted by volunteers at two study remnants was established in Part II. This section presents the results of monitoring of these remnants over a two-year period, using the indicators of vigour, organization and resilience, as described in Part I. Given the differences between the reserves, the duration of observations and the individuals who performed the monitoring, comparative statistical analysis cannot be drawn and the paper is, therefore, mainly descriptive.

METHODOLOGY

HISTORY

For Goomalling, the history of the area was researched in "Goomalling, a backward glance: a history of the district" (Sewell 1998) and members of the local community were interviewed.

For Franklandia, information was taken from the Draft Management Plan, and members of the local community were interviewed.

Categories of interest and questioning referred to both natural and cultural histories and past and present use.

MONITORING ROUTINE

In total, 12 field trips were made to each reserve between October 1999 and July 2001. At each reserve, observers rotated through the four sites, spending 20 minutes at each site, on two mornings per field trip. Full details of the monitoring routine is detailed in Part I.

VEGETATIVE GROWTH AND RECRUITMENT

Floral diversity

Species lists were made of all plants within the 10 m x 10 m quadrats at both reserves. Identification of most plant species was made by local botanists and the identification of many species was verified at the Western Australian Herbarium. Nomenclature follows Paczcowska and Chapman (2000).

Recruitment

In March 2000, at each reserve, two sides of each of the 10m x 10m quadrats

were extended to produce 30m x 30m quadrats. The 30m x 30m quadrats were assessed for the presence of trees and shrubs, saplings and seedlings; herbaceous plants were not included for this part of the study. During the assessment, tape measures and ropes, marked off in one-metre lengths, were placed on the perimeter of the quadrats. Using alphanumeric coordinates, the number of trees and shrubs were counted in each square metre and summed for the quadrat, and then summed for each reserve. Three size categories were used: less than two metres, two to ten metres and greater than ten metres.

DIVERSITY OF THE BIOTIC COMPONENT

Birds

No significant differences were demonstrated in the interaction between reserves and observer in terms of the numbers of birds seen and heard and the number of bird species seen and heard (see Part II). Therefore, data in this section will be presented as the combined total of the number of individual birds seen and heard and the combined total of the number of bird species seen and heard at each reserve.

Nomenclature follows Christidis and Boles (1994).

Invertebrates

Volunteers and the biologist recorded invertebrates as described in Part I. No significant differences were demonstrated in the interaction between reserves and observer in terms of the numbers of invertebrates seen and the number of orders of invertebrates seen (see Part II). Therefore, data are presented as the total number of invertebrates seen and the total numbers of orders of invertebrates seen at each reserve. Nomenclature follows "The Insects of Australia" (CSIRO 1970).

Mammals

At the beginning of the project, each site was examined in terms of potential mammalian activity. Such indicators included trees with hollows and runways alongside vegetation. Having selected an appropriate site within each site, an area measuring approximately 3m x 1m was cleared of all vegetation and covered with a layer of fine sand brought from elsewhere in the reserve. The evening before each monitoring session, sand pads were cleared of any debris, raked to loosen the top layer of sand and smoothed with a fine brush so that indentations of any mammal that landed on the pad or crossed it would remain for inspection and identification.

During each morning of monitoring, sand pads were inspected for evidence of mammalian activity. Other evidence, such as tree scratchings, diggings or faeces were searched for and recorded.

Nomenclature follows Strahan (1995).

DISTURBANCE, DEGRADATION AND SEED ASSESSMENT

Recreational use

Evidence of use, such as vehicle and trail-bike tracks and fires anywhere in the reserve were noted. Evidence of timber cutting and other activities were recorded.

Degradation

Study sites, the immediate area around

the study sites, the reserve in general and areas beyond the reserve were examined for evidence of salinity and erosion.

Soil seed-banks

At each of the four extended quadrats (30 m x 30 m) in each reserve, 20 soil samples were collected in March 2000. Each sample consisted of a soil core of 20 cm x 20 cm, removed at depths of 0 – 2 cm and 2 – 5 cm. The samples were germinated at Kings Park and Botanic Gardens. Details of this satellite study are published in Saffer *et al.* (2002). A summary of the findings is provided in this report.

ANALYSIS

As the sampling intensity differed between field trips in terms of the numbers of observers and minutes of observations, comparisons were made in terms of data per person minutes.

OUTCOMES AND RESULTS

HISTORY

Goomalling

Goomalling, formerly also known as Coomarin and Coomallyn, is the Aboriginal name derived from "kumarl" or "koomal" meaning possum, and "ing" meaning "the place of" (Sewell 1998). The "place of the possums" was named after the Common Brushtail Possum (*Trichosurus vulpecula*) which was once abundant in the area (Sewell 1998). The Balardong people, a tribe of about 55 and members of the thirteen Nyungar tribes of south-western Australia, occupied the Goomalling district prior to white settlement. The reserve was used as a hunting ground for food. Although Nyungars practice this tradition today, kangaroo hunting in the reserve is now infrequent.

Goomalling is the larger of the two reserves studied and is diamond to oval in shape. Water holes are not present in the reserve and the nearest natural water source is a group of small lakes at Oak Park, 15 km north east of Goomalling. The reserve has no history of stock grazing or fire for at least 80 years

The reserve is unfenced and not actively managed. Indiscriminate vehicular and trail bike tracks traverse the reserve and evidence remains of past and present timber collection and dumping of soil and other refuse.

Accounts of the mammalian populations at Goomalling differ considerably. Some residents believe the population of the Euro (*Macropus robustus*) has diminished over the years, others believe that there is an increase in numbers as the Nyungars no longer hunt them consistently. Similarly, some residents state that the Common Brushtail Possum is no longer present in the reserve, while others suggest that they could be found throughout the reserve. No reports of sightings of the Short-beaked Echidna (*Tachyglossus aculeatus*) were recorded. However, diggings had been identified in properties adjacent to the reserve.

Horses were ridden regularly through the reserve about 40 years ago. Foxes (*Vulpes vulpes*) have been in the reserve for many years. However, numbers have decreased over time. Rabbits (*Oryctolagus cuniculus*) and the feral domestic cat (*Felis catus*) have both been sighted in the reserve but neither were reported to have been abundant.

Franklandia

Franklandia was declared a reserve in 1886 and has retained that status to the present day. It is named after the only priority plant species, *Franklandia triaristrata*, known in the reserve. This plant was named after the English botanist, Sir Thomas Frankland (1750 – 1831). In 1985, the local council attempted to use the land for the supply of sand. However, officers of the Department of Conservation and Land Management (CALM) recognized its value and the importance of preserving the vegetation, and opposed the application by the council. In 1995, following an environmental survey of the land, members of the Bunbury Naturalists' Club agreed to participate with CALM in the management of the reserve. Thirteen car bodies were removed from the reserve, in addition to approximately 20 cubic metres of rubbish. Fencing surrounding the entire reserve was secured, lockable gates were installed and signs were erected.

Franklandia is one-fifth the size of Goomalling and is rectangular in shape. An area of 8361 m^2 in the north-west corner contains a Main Roads WA radio base and is fenced off. Tracks surrounding the reserve were maintained as firebreaks, whereas tracks that traversed the reserve were left to grow over. Small, contained fires occurred in 1981, 1995 and 1996.

Inquiries of the local Aboriginal Corporation and the Department of Aboriginal Affairs produced no evidence of Nyungar interest in the area.

Before the fence was secured, the reserve was used extensively by people for varied purposes. Activities included horse riding, trail-biking, a dumping site for car bodies and other refuse and timber collection.

Western Grey Kangaroos (*Macropus fuliginosus*) had gradually increased in number: local farmers expressed concern as the increasing population of kangaroos was damaging fencing and competing with cattle for food resources. The Common Brushtail Possum was present prior to 1995 but has not been reported since. Of the feral mammals, foxes, rabbits and cats had all been sighted within the reserve. While fox numbers has increased, the number of rabbits has decreased.

MONITORING SESSIONS:

Volunteers attended 26 mornings during 12 field trips to each reserve from October 1999 to July 2001. Collectively, 32 volunteers visited Goomalling 176 times and 31 individuals made 169 visits to Franklandia. Together with the author, a total of 264 hours of observations were made at Goomalling and 262 hours of observations were made at Franklandia.

VEGETATIVE GROWTH AND RECRUITMENT

Floral diversity

The vegetation at Goomalling consists of a mixed eucalypt woodland with York Gum (*Eucalyptus loxophleba* subsp. *loxophleba*), Gimlet (*E. salubris*), Salmon Gum (*E. salmonophloia*) and Red Morrel (*E. longicornis*) dominating, and an open understorey on loamy soils (Appendix 1). Forty-nine species from 17 families were recorded. Of these 44 species were native and five non-native.

Jarrah (*Eucalyptus marginata*) and

Banksia species dominate the vegetation at Franklandia with a moderate to highly dense understorey on sandy soils (Appendix 2). A dense sedge swamp covers a small area at the western boundary. Native species numbered 111 from 28 families with Blowfly Grass (*Briza maxima*) and South African Orchid (*Disa bracteata*) the only non-natives in the quadrats.

A similar number of tree species was recorded at both reserves. Herbs outnumbered shrubs at Goomalling whereas shrubs and perennial herbs were more profuse at Franklandia. A full report of the vegetation at both reserves appears in Saffer *et al.* (2002).

Recruitment

Nine species of trees and shrubs were recorded in each reserve in the 30 m x 30 m quadrats. For Goomalling, of the 397 trees and shrubs recorded, 13 were greater than 10 metres, 158 were less than two metres and the remaining 226 were between two and 10 metres (Table 1). Many more trees and shrubs were recorded for Franklandia (1420) with a majority (891) less than two metres (Table 1). Twenty trees were greater than 10 metres and the remaining (509) were between two and ten metres.

Table 1. Trees and shrubs in four (30 m x 30 m) quadrats at Goomalling and Franklandia in three size categories.

Species		Size (metres)		
Common name	Scientific name	>10 m	2 m - 10 m	< 2 m
Goomalling				
-	*Acacia aestivalis*	25	68	92
Jam	*Acacia acuminata*		75	9
-	*Acacia ligustrina*		29	2
Needle Tree	*Hakea preissii*		5	22
Salmon Gum	*Eucalyptus salmonophloia*	8	13	2
-	*Allocasuarina campestris*		12	6
York Gum	*Eucalyptus loxophleba*	3	12	1
Rock Sheoak	*Allocasuarina huegeliana*		8	
Gimlet	*Eucalyptus salubris*	1	4	
Total		37	226	134
Franklandia				
Peppermint Tree	*Agonis flexuosa*		4	1
Slender Banksia	*Banksia attenuata*	6	95	74
Bull Banksia	*Banksia grandis*	1	1	16
Holly-leaved Banksi	*Banksia ilicifolia*	4	13	10
Jarrah	*Eucalyptus marginata*	7	34	204
Spearwood	*Kunzea ericifolia*	2	337	495
Moonah	*Melaleuca preissiana*		9	
Christmas Tree	*Nuytsia floribunda*		9	79
Forest Woody Pear	*Xylomelum occidentale*		8	12
Total		20	510	891

DIVERSITY OF THE BIOTIC COMPONENT

Birds

Overall, 9525 birds from 58 species were recorded at Goomalling and 7314 birds from 56 species were identified at Franklandia. Collectively, 81 species were identified, with 35 species common to both reserves (Table 2). The 24 species identified at Goomalling but not at Franklandia accounted for 48% of all birds recorded at Goomalling. Within this category, the Galah (*Cacatua roseicapilla*) accounted for nearly half (45%) of the birds seen only at Goomalling, and 21% of all records at Goomalling. The 22 species identified at Franklandia but not at Goomalling accounted for 19% of all birds recorded at Franklandia.

At Goomalling, more birds were recorded in the summer months and the least number in the spring (Table 2). Conversely, at Franklandia, more birds were recorded in the spring months and the least number in the summer.

Invertebrates

Overall, 5160 invertebrates from 17 orders were recorded at Goomalling and 5753 invertebrates from 16 orders were recorded at Franklandia. Fourteen orders were common to both reserves (Table 3). Invertebrates within orders that were not common to both reserves accounted for less than 1% of all invertebrates at each reserve. For example, one springtail (Collembola) (0.02%), two earwigs (Dermaptera) (0.04%) and one silverfish (Thysanoptera) (0.02%) was recorded at Goomalling but not at Franklandia, while one scorpion fly (Mecoptera) (0.02%) and six caddis fly (Tricoptera) (0.1%) were recorded at Franklandia but not at Goomalling.

At Goomalling, Hymenoptera, Arachnidae and Diptera accounted for 86% of all invertebrates, while at Franklandia, Diptera and Hymenoptera accounted for 76% of all invertebrates recorded. Feral bees (*Apis mellifera*) were recorded at both reserves. However, feral bees represented 3.6% of Hymenoptera at Goomalling and 60% of Hymenoptera at Franklandia. A feral beehive was active in one of the monitoring sites at Franklandia for the duration of the monitoring surveys. Fewer invertebrates were recorded during the colder months at both reserves (Table 3).

Mammals

Of the native mammals at Goomalling, Euros were seen during seven of the 12 field trips. Evidence of Euros and Common Brushtail Possums were recorded during all field trips. Fresh diggings of the Short-beaked Echidna were evident in eight of the 12 field trips.

For the non-native mammals at Goomalling, two foxes were seen, and fox tracks and fox scats were identified in eight of the 12 field trips. Domestic dog tracks were identified in five field trips and rabbit diggings and droppings were present in four of the field trips. Feral domestic cats were seen on three occasions and tracks were visible in four of the 12 field trips.

At Franklandia, Western Grey Kangaroos were seen during nine of the 12 field trips and evidence of their presence was recorded during all field trips. Common Brushtail Possum scats were collected during only the second

Table 2. Seasonal variation in the number of individual birds recorded per person/minute and the number of bird species at Goomalling and Franklandia. Species common to both reserves are in bold.

Common name (*Scientific name*)	Goomalling				Franklandia			
	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer
Stubble Quail (*Coturnix pectoralis*)				0.0019				
Australian Shelduck (*Tadorna tadornoides*)		0.0182			0.0007	0.0108	0.0044	
Australian Wood Duck (*Chenonetta jubata*)	0.0005		0.0014			0.0014	0.0008	
Pacific Black Duck (*Anas superciliosa*)						0.0009	0.0005	
White-faced Heron (*Egretta novaehollandiae*)					0.0002	0.0009	0.0005	
Australian White Ibis (*Threskiornis molucca*)							0.0031	0.0019
Straw-necked Ibis (*Threskiornis spinicollis*)					0.0167	0.0043	0.0070	0.0027
Black-shouldered Kite (*Elanus axillaris*)	0.0013		0.0007					
Whistling Kite (*Haliastur sphenurus*)								0.0005
Spotted Harrier (*Circus assimilis*)		0.0003	0.0059	0.0008				
Brown Goshawk (*Accipiter fasciatus*)	0.0005		0.0002				0.0005	
Wedge-tailed Eagle (*Aquila audax*)	0.0003		0.0005	0.0005			0.0016	0.0016
Little Eagle (*Hieraaetus morphnoides*)		0.0003	0.0019					
Brown Falcon (*Falco berigora*)								0.0003
Australian Hobby (*Falco longipennis*)					0.0002			
Nankeen Kestrel (*Falco cenchroides*)	0.0013							
Common Bronzewing (*Phaps chalcoptera*)			0.0005	0.0005	0.0002	0.0003	0.0003	0.0011
Crested Pigeon (*Ocyphaps lophotes*)	0.0038	0.0022	0.0042	0.0092				
Red-tailed Black-Cockatoo (*Calyptorhynchus banksii*)					0.0063			
Short-billed Black-Cockatoo (*Calyptorhynchus latirostris*)					0.0042	0.0139	0.0086	
Galah (*Cactua roseicapilla*)	0.1589	0.1413	0.1295	0.2092				
Western Corella (*Cacatua pastinator*)	0.0156	0.0610	0.0493	0.0125				
Purple-crowned Lorikeet (*Glossopsitta porphyrocephala*)					0.0002			
Regent Parrot (*Polytelis anthopeplus*)								0.0052
Western Rosella (*Platycercus icterotis*)					0.0060	0.0060	0.0122	0.0014
Australian Ringneck (*Barnardius zonarius*)	0.0574	0.0995	0.0458	0.0818	0.0554	0.0622	0.0721	0.0438
Red-capped Parrot (*Purpureicephalus spurius*)					0.0112	0.0071	0.0052	0.0035
Elegant Parrot (*Neophema elegans*)			0.0009			0.0045	0.0016	

Fan-tailed Cuckoo (*Cacomantis flabelliformis*)	0.0003					0.0017	0.0010	
Black-eared Cuckoo (*Chrysococcyx osculans*)		0.0025	0.0005	0.0003				
Horsfield's Bronze-Cuckoo (*Chrysococcyx basalis*)		0.0015	0.0002				0.0003	
Shining Bronze-Cuckoo (*Chrysococcyx lucidus*)		0.0015	0.0005			0.0014	0.0047	0.0022
Southern Boobook (*Ninox novaeseelandiae*)							0.0003	
Tawny Frogmouth (*Podargus strigoides*)				0.0016				
Australian Owlet-nightjar (*Aegotheles cristatus*)		0.0008						
Laughing Kookaburra (*Dacelo novaeguineae*)	0.0046	0.0032	0.0045	0.0046	0.0036	0.0011	0.0068	0.0038
Sacred Kingfisher (*Todiramphus sanctus*)			0.0052	0.0014			0.0018	0.0024
Rainbow Bee-eater (*Merops ornatus*)	0.0003		0.0021	0.0429	0.0237		0.0049	0.0063
Splendid Fairy-wren (*Malurus splendens*)					0.0150	0.0267	0.0315	0.0133
Striated Pardalote (*Pardalotus striatus*)	0.0316	0.0200	0.0316	0.0234	0.0080	0.0048	0.0151	0.0144
White-browed Scrubwren (*Sericornis frontalis*)					0.0009	0.0009	0.0008	
Weebill (*Smicrornis brevirostris*)	0.0395	0.0323	0.0288	0.0326				
Western Gerygone (*Gerygone fusca*)	0.0064	0.0075	0.0090	0.0052	0.0201	0.0142	0.0424	0.0163
Inland Thornbill (*Acanthiza apicalis*)	0.0094	0.0022	0.0071	0.0149	0.0259	0.0233	0.0177	0.0261
Chestnut-rumped Thornbill (*Acanthiza uropygialis*)	0.0051	0.0022	0.0017	0.0082				
Western Thornbill (*Acanthiza inornata*)	0.0105	0.0138	0.0047	0.0117	0.0007	0.0014	0.0018	
Yellow-rumped Thornbill (*Acanthiza chrysorrhoa*)	0.0270	0.0067	0.0050	0.0130	0.0018	0.0031	0.0026	0.0011
Red Wattlebird (*Acanthochaera carunculata*)	0.0028	0.0008		0.0003	0.0134	0.0045	0.0211	0.0177
Little Wattlebird (*Acantochaera chrysoptera*)	0.0003		0.0007					
Spiny-cheeked Honeyeater (*Acanthagenys rufogularis*)	0.0018	0.0022		0.0041				
Yellow-throated Miner (*Manorina flavigula*)	0.0278	0.0073	0.0104	0.0158				
Singing Honeyeater (*Lichenostomus virescens*)	0.0015	0.0003	0.0002	0.0005	0.0007		0.0003	
Brown-headed Honeyeater (*Melithreptus brevirostris*)	0.0023	0.0077	0.0017	0.0027				
Brown Honeyeater (*Lichmera indistincta*)	0.0023	0.0035	0.0061		0.0096	0.0131	0.0701	0.0383
New Holland Honeyeater (*Phylidonyris novaehollandiae*)						0.0003		
Western Spinebill (*Acanthorynchus superciliosus*)					0.0194	0.0134	0.0086	0.0171
White-fronted Chat (*Epthianura albifrons*)			0.0014					
Jacky Winter (*Microeca fascinans*)			0.0017	0.0005				
Scarlet Robin (*Petroica multicolor*)					0.0029	0.0085	0.0047	0.0043
Red-capped Robin (*Petroica goodenovii*)	0.0061	0.0120	0.0083	0.0063				
Hooded Robin (*Melanodryas cucullata*)		0.0005						

Table 2. (cont.)

Common name (*Scientific name*)	Goomalling				Franklandia			
	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer
Western Yellow Robin (*Eopsaltria griseogularis*)					0.0002			
White-browed Babbler (*Pomatostomus superciliosus*)	0.0107	0.0090	0.0097	0.0152				
Varied Sittella (*Daphoenositta chrysoptera*)					0.0018	0.0006		
Golden Whistler (*Pachycephala pectoralis*)	0.0078	0.0156	0.0070	0.0087				
Rufous Whistler (*Pachycephala rufiventris*)	0.0059	0.0047	0.0146	0.0082	0.0087	0.0080	0.0078	0.0082
Grey Shrike-thrush (*Colluricincia harmonica*)	0.0028	0.0032	0.0113	0.0052	0.0011	0.0040	0.0081	0.0027
Magpie-lark (*Grallina cyanoleuca*)	0.0018	0.0003	0.0017	0.0022	0.0054	0.0071	0.0036	0.0016
Grey Fantail (*Rhipidura fuliginosa*)	0.0105	0.0205	0.0061	0.0022	0.0393	0.0440	0.0529	0.0234
Willie Wagtail (*Rhipidura leucophrys*)	0.0010			0.0008	0.0033	0.0006	0.0008	0.0005
Black-faced Cuckoo-shrike (*Coracina novaehollandiae*)	0.0107	0.0055	0.0061	0.0098	0.0027	0.0026	0.0052	0.0022
Ground Cuckoo-shrike (*Coracina maxima*)	0.0005							
White-winged Triller (*Lalage sueurii*)			0.0014					
Dusky Woodswallow (*Artamus cyanopterus*)			0.0005	0.0008	0.0080	0.0153	0.0068	0.0052
Grey Butcherbird (*Cracticus torquatus*)	0.0051	0.0013	0.0026	0.0082	0.0087	0.0060	0.0070	0.0054
Pied Butcherbird (*Cracticus nigrogularis*)	0.0046	0.0063	0.0035	0.0046				
Australian Magpie (*Gymnorhina tibicen*)	0.0224	0.0120	0.0104	0.0187	0.0248	0.0301	0.0271	0.0133
Australian Raven (*Corvus coronoides*)	0.0684	0.0583	0.0417	0.0440	0.0339	0.0327	0.0469	0.0266
Welcome Swallow (*Hirundo neoxena*)	0.0013	0.0013		0.0003	0.0031	0.0017	0.0008	
Tree Martin (*Hirundo nigricans*)	0.0204	0.0210	0.0347	0.0133	0.0033	0.0006	0.0089	0.0101
Rufous Songlark (*Cincloramphus mathewsi*)			0.0007					
Silvereye (*Zosterops lateralis*)	0.0033	0.0092	0.0087	0.0068	0.0118	0.0082	0.0021	0.0109
Total number of birds	0.1158	0.1018	0.0962	0.0832	0.3933	0.3895	0.5214	0.3370
Number of species	42	40	48	42	41	41	47	36

Table 3. Number of invertebrates per person/minute and number of orders recorded during four seasons at Goomalling and Franklandia. Percentage of feral bees within Hymenoptera are shown.

Order	Goomalling				Franklandia			
	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter
Collembola			0.0002					
Arachnida	0.0818	0.0418	0.0270	0.0938	0.0137	0.0204	0.0058	0.0035
Odonata	0.0083	0.0075	0.0027	0.0015	0.0356	0.0231	0.0026	
Plecoptera	0.0011	0.0002	0.0011	0.0002	0.0030	0.0007	0.0008	
Blattodea	0.0006	0.0002		0.0009	0.0002		0.0012	0.0003
Isoptera	0.0106	0.0260	0.0068	0.0026	0.0162	0.0048	0.0022	0.0203
Mantodea	0.0004	0.0002	0.0007					0.0003
Dermaptera			0.0002	0.0002				
Orthoptera	0.0121	0.0154	0.0032	0.0047	0.0097	0.0233	0.0117	0.0018
Phasmatodea	0.0006	0.0005				0.0007	0.0002	
Hemiptera	0.0044	0.0072	0.0011	0.0006	0.0035	0.0231	0.0054	0.0008
Thysanoptera		0.0002						
Neuroptera	0.0006		0.0002			0.0010		0.0003
Coleoptera	0.0004	0.0014	0.0007	0.0013	0.0093	0.0043	0.0006	0.0005
Mecoptera					0.0002			
Diptera	0.0458	0.0394	0.0314	0.0444	0.2556	0.0962	0.0554	0.0605
Tricoptera					0.0011	0.0002		
Lepidoptera	0.0191	0.0058	0.0073	0.0073	0.0421	0.0178	0.0111	0.0030
Hymenoptera	0.1621	0.2115	0.1177	0.0894	0.2035	0.1623	0.1056	0.0615
Others		0.0007						
Total number of invertebrates	0.348	0.358	0.200	0.247	0.553	0.378	0.203	0.153
Number of order	14	14	14	12	13	13	12	11
% feral bees within Hymenoptera	2.9	3.6	0.8	8.4	55.6	58.1	58.8	81.7

last of the field trips and no other evidence of their presence was reported or recorded throughout the monitoring period. Of the non-native mammals, foxes were sighted on three occasions, with tracks and scats scored during 11 field trips. Rabbits were seen during six field trips and diggings and fresh droppings were evident during all field trips. Rabbit warrens were identified close to two of the four monitoring sites. One cat was seen in June 2000 during a winter field trip and no other evidence of cats was recorded.

DISTURBANCE, DEGRADATION AND SEED ASSESSMENT

Recreational use

Evidence of human presence was recorded during every field trip to Goomalling. Vehicle and trail-bike tracks were always present. One resident of Goomalling exercised his dog in the reserve every day until advised to do so elsewhere. The same individual admitted that within the reserve, he killed one kangaroo each week to feed his dog. Trees were cut for timber on

one occasion, two vehicles with trailers full of freshly-sawn wood were seen leaving the reserve and on two further, separate occasions, individuals with chain saws were seen sawing wood and removing it from the reserve. An area near one of the sites had been set up with logs for seating surrounding an open fire, and was used irregularly during the two-year period. Timber from the immediate area was used to fuel the fire. Soil and soil/concrete mix was dumped in the reserve on at least three occasions during the two-year monitoring period, in close proximity to the many other loads that had been dumped prior to the commencement of this study.

At Franklandia, the fence and locked gate prevented vehicle and bike access but permited public access. Members of the public used the reserve for bush walks.

Degradation

Evidence of salinity or erosion was not apparent at Goomalling or Franklandia. However, dieback was noted in some banksia trees adjacent to one of the sites at Franklandia.

Although rabbits were present at both reserves, rabbit warrens were evident only at Franklandia. Fox lairs were not identified at either reserve.

Soil seed-banks

Detailed results of the soil seed-bank study are available in Saffer *et al.* (2002). Therefore, only a brief synopsis is presented in this paper.

A total of 8024 germinants were scored from soil samples at Goomalling and 3897 from Franklandia. Native species accounted for 70% of germinants from Goomalling and 61% from Franklandia. Most seeds (71% and 68% in Goomalling and Franklandia respectively) were present in the top 2 cm of soil rather than lower in the soil profile (2 cm – 5 cm). Differences in vegetation composition overall, were concentrated in species in which seed is not stored in the canopy, and in particularly, species in the understorey and ground layers. Annuals dominated the predominant herbaceous layer at the drier wheatbelt site of Goomalling and perennial herbs and shrubs were more profuse at Franklandia on the moister Swan Coastal Plain.

DISCUSSION

Members of the Toodyay/Goomalling and Bunbury communities, under my direction, were largely responsible for the monitoring of Goomalling and Franklandia. Similar numbers from each community participated in the project and the hours of observation were comparable for both reserves. Volunteers felt that the project had been a great learning experience for them: most had an improved awareness of ecosystem elements and had gained skills of identification during the monitoring process (see Part II).

An overall critical assessment of the two reserves revealed similarities in that neither had had a major fire for almost a century and neither had been grazed for equally as long. While recruitment of vegetation was evident at both, it was not unexpected that recruitment at Franklandia was far greater than that at Goomalling, which receives about a third of the annual rainfall of Franklandia. Similarly, it was not surprising that there were more seeds in

the soil-seed bank at Goomalling than at Franklandia, with higher rainfall at Franklandia providing the cue required for many species to germinate. Nevertheless, both reserves exhibited regenerative potential.

Diversity of the biotic component was evident at both reserves. While larger, open country bird species were recorded at both reserves, these made up a greater percentage of birds seen at Goomalling than at Franklandia. Smaller bird species which require shrubs and bushes for movement, shelter and food were also present at both reserves, but accounted for a greater percentage of birds at Franklandia, which supported more shrubs and perennial herbs than Goomalling. Seasonal differences in the numbers of birds suggest that observations performed once during the year would not be sufficiently reliable to monitor general bird use of the reserves. Furthermore, depending on the time of recording, migratory species, such as the Rainbow Bee-eater (*Merops ornatus*) and Sacred Kingfisher (*Todiramphus sanctus*), could be missed entirely.

Similarly, invertebrate activity changed seasonally with fewer individuals present during the colder months. Therefore, observations taken only during the winter, for example, would not provide an accurate assessment of the overall presence of invertebrates at that site. The diversity of invertebrates, while substantial, was not vastly different between reserves. Significantly, there were more feral bees at Franklandia where moister conditions were likely to support greater numbers of bees for longer periods of time.

Foxes, cats and rabbits were present at both reserves and need to be eradicated. It is likely that the greater size of Goomalling has allowed the persistence of the Common Brushtail Possum. While there was some evidence of the Common Brushtail Possum at Franklandia, the presence of the fox, the small size and shape of the reserve with no refugia adjacent to the reserve, were not conducive to their persistence at Franklandia. If the population of Western Grey Kangaroos at Franklandia was allowed to increase, the effect of their grazing would become deleterious. This highlights the importance of on-going monitoring: while one set of observations is informative, the changing status of mammals and vegetation would provide a more comprehensive assessment of the health of the reserve under study.

Similarly, the on-going use of reserves by people must be considered. For Franklandia, fencing and signage educated the public and prevented any more than pedestrian access. At Goomalling, the public were mostly unaware that the bushland was a reserve and, as such, certain activities were not allowed within the reserve. While the volunteers and their associates became more aware of the value of their reserves, the education of the broader public at Goomalling had to be addressed. During the tenure of the project, the Goomalling Bushland Management Group was established with representatives from the Nyungar community, farmers, shire council representative, government sponsored landcare coordinators and other residents within the shire. Signs were erected, an education program was being planned and management plans for the Goomalling reserve and other reserves within the shire were commenced. As the cost of fencing Goomalling reserve is prohibitive for the

shire, the importance of public education is paramount.

GENERAL CONCLUSIONS

Goomalling and Franklandia are two of many patches of remnant vegetation remaining in the south-west of Western Australia. Differences in the location, management, climate, edaphic features and associated differences provide an array of attributes typical of many woodland remnants in the south-west. While it was possible for volunteers at each reserve to comment on the overall health of their reserve, these comments naturally included some subjectivity, and any comparisons with any other reserve(s) were unsubstantiated. A more reliable tool of assessment, which reduces subjectivity and allows realistic comparisons, requires a standardised form that can be used for all reserves. The results of this study, collectively, provided sufficient information with which to design a means of assessing the health of varied patches of remnant vegetation. Requirements for such an assessment tool require critical evaluation of the frequency and duration of observations, species monitored and interpretation of the results. The product of this evaluation and examples of this tool, using the reserves as described above, appear in Part IV.

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Appendix 1. Plant species in life-form categories from Goomalling Reserve. Nomenclature follows Paczkowska and Chapman (2000).

Species Common name	Scientific name	Family
Native species		
Trees		
Jam	*Acacia acuminata*	Mimosaceae
–	*Acacia aestivalis*	Mimosaceae
Rock Sheoak	*Allocasuarina huegeliana*	Casuarinaceae
Red Morrel	*Eucalyptus longicornis*	Myrtaceae
York Gum	*Eucalyptus loxophleba*	Myrtaceae
Salmon Gum	*Eucalyptus salmonophloia*	Myrtaceae
Gimlet	*Eucalyptus salubris*	Myrtaceae
Needle Tree	*Hakea preissii*	Proteaceae
Christmas Tree	*Nuytsia floribunda*	Loranthaceae
Shrubs		
–	*Acacia bidentata*	Mimosaceae
–	*Acacia erinacea*	Mimosaceae
–	*Acacia ligustrina*	Mimosaceae
–	*Allocasuarina campestris*	Casuarinaceae
Dwarf Sheoak	*Allocasuarina humilis*	Casuarinaceae
–	*Astroloma* sp.	Epacridaceae
Hastate Orache	*Atriplex prostrata*	Chenopodiaceae
–	*Bassia* sp.	Chenopodiaceae
–	*Dampiera* sp.	Goodeniaceae
Barrier Saltbush	*Enchylaena tomentosa*	Chenopodiaceae
–	*Eremophila drummondii*	Myoporaceae
–	*Grevillea huegelii*	Proteaceae
–	*Grevillea paniculata*	Proteaceae
–	*Nemcia acuta*	Papilionaceae
Herbs		
Perennial		
–	*Amphipogon* sp.	Poaceae
Feather Speargrass	*Austrostipa elegantissima*	Poaceae
–	*Borya* sp.	Anthericaceae
Blue Squill	*Chamaescilla corymbosa*	Anthericaceae
–	*Conostylis* sp.	Haemodoraceae
–	*Danthonia* sp.	Poaceae
Blueberry Lily	*Dianella revoluta*	Phormiaceae
–	*Dichopogon preissii*	Anthericaceae
Bridal Rainbow	*Drosera macrantha*	Droseraceae
Pink Rainbow	*Drosera menziesii*	Droseraceae

Species Common name	Scientific name	Family
Foxtail Mulga Grass	*Neurachne alopecuroidea*	Poaceae
Narrowleaf Mulla Mulla	*Ptilotus drummondii*	Amaranthaceae
Annual		
Mediterranean Turnip	*Brassica tournefortii*	Brassicaceae
–	*Gilberta tenuifolia*	Asteraceae
–	*Lawrencella rosea*	Asteraceae
Wiry Podolepis	*Podolepsis capillaris*	Asteraceae
–	*Podolepsis lessonii*	Asteraceae
Golden Long-heads	*Podotheca gnaphalioides*	Asteraceae
–	*Rhodanthe citrina*	Asteraceae
–	*Rhodanthe manglesii*	Asteraceae
Orange Immortelle	*Waitzia acuminata*	Asteraceae
–	*Waitzia nitida*	Asteraceae
Non-native species		
Herbs		
Annual		
Silvery hairgrass	*Aira caryophyllea*	Poaceae
Bearded oat	*Avena barbata*	Poaceae
Blowfly grass	*Briza maxima*	Poaceae
Annual Veldtgrass	*Ehrharta longiflora*	Poaceae
Ursinia	*Ursinia anthemoides*	Asteraceae

Appendix 2. Plant species in life-form categories from Franklandia Reserve. Nomenclature follows Paczkowska and Chapman (2000).

Species Common name	Scientific name	Family
Native species		
Trees		
Peppermint Tree	*Agonis flexuosa*	Myrtaceae
Slender Banksia	*Banksia attenuata*	Proteaceae
Bull Banksia	*Banksia grandis*	Proteaceae
Holly-leaved Banksia	*Banksia ilicifolia*	Proteaceae
Marri	*Corymbia calophylla*	Myrtaceae
Jarrah	*Eucalyptus marginata*	Myrtaceae
Moomah	*Melaleuca preissiana*	Myrtaceae
Forest Woody Pear	*Xylomelum occidentale*	Proteaceae
Shrubs		
Wiry Wattle	*Acacia extensa*	Mimosaceae
–	*Acacia flagelliformis*	Mimosaceae
Prickly Moses	*Acacia pulchella*	Mimosaceae
–	*Acacia semitrullata*	Mimosaceae
–	*Adenanthos meisneri*	Proteaceae
Basket Flower	*Adenanthos obovatus*	Proteaceae
Dwarf Sheoak	*Allocasuarina humilis*	Casuarinaceae
Foxtails	*Andersonia caerulea*	Epacridaceae
–	*Astartea fascicularis*	Myrtaceae
–	*Boronia dichotoma*	Rutaceae
Common Brown Pea	*Bossiaea eriocarpa*	Papilionaceae
–	*Calothamnus lateralis*	Myrtaceae
Summer Starflower	*Calytrix flavescens*	Myrtaceae
Pink Summer Calytrix	*Calytrix fraserii*	Myrtaceae
Blue-spike Milkwort	*Comesperma calymega*	Polygalaceae
–	*Conospermum capitatum*	Proteaceae
–	*Conostephium preissii*	Epacridaceae
–	*Daviesia physodes*	Papilionaceae
Swamp Pea	*Euchilopsis linearis*	Papilionaceae
Yellow Pea	*Gompholobium capitatum*	Papilionaceae
Hairy Yellow Pea	*Gompholobium tomentosum*	Papilionaceae
Native Wisteria	*Hardenbergia comptoniana*	Papilionaceae
Snakebush	*Hemiandra pungens*	Lamiaceae
Stalked Guinea Flower	*Hibbertia racemosa*	Dilleniaceae
Yellow Buttercups	*Hibbertia hypericoides*	Dilleniaceae
–	*Hibbertia vaginata*	Dilleniaceae
Common Hovea	*Hovea trisperma*	Papilionaceae
White Myrtle	*Hypocalymma angustifolium*	Myrtaceae

Species Common name	Scientific name	Family
Stnikwood	*Jacksonia sternbergiana*	Papilionaceae
Spearwood	*Kunzea ericifolia*	Myrtaceae
–	*Kunzea recurva*	Myrtaceae
Spiked Beard-heath	*Leucopogon australis*	Epacridaceae
–	*Leucopogon oxycedrus*	Epacridaceae
–	*Leucopogon polymorphus*	Epacridaceae
–	*Leucopogon propinquus*	Epacridaceae
Curry Flower	*Lysinema ciliatum*	Epacridaceae
–	*Melaleuca thymoides*	Myrtaceae
Swamp Teatree	*Pericalymma ellipticum*	Myrtaceae
Snottygobble	*Persoonia longifolia*	Proteaceae
Snottygobble	*Persoonia saccata*	Proteaceae
Pixie Mops	*Petrophile linearis*	Proteaceae
Pepper and Salt	*Philotheca spicatus*	Rutaceae
–	*Platytheca galiodes*	Tremandraceae
Royal Robe	*Scaevola striata*	Goodeniaceae
–	*Stackhousia monogyna*	Stackhousiaceae
Blueboy	*Stirlingia latifolia*	Proteaceae
Herbs		
Perennial		
Blue Grass Lily	*Agrostocrinum scabrum*	Anthericaceae
–	*Amphipogon turbinatus*	Poaceae
–	*Anarthria prolifera*	Restionaceae
Mangles Kangaroo Paw	*Anigozanthis manglesii*	Haemodoraceae
Milkmaids	*Burchardia umbellata*	Colchicaceae
Pale Grass Lily	*Caesia micrantha*	Anthericaceae
Blue Squill	*Chamaescilla corymbosa*	Anthericaceae
–	*Conostylis* sp.	Haemodoraceae
Wedge-leaved Dampiera	*Dampiera linearis*	Goodeniaceae
Pineapple Bush	*Dasypogon bromeliifolius*	Dasypogonaceae
–	*Drosera erythrorhiza* spp. *erythrorhiza*	Droseraceae
–	*Drosera menziesii* spp. *penicillaris*	Droseraceae
Dwarf Sundew	*Drosera paleacea*	Droseraceae
Pretty Sundew	*Drosera pulchella*	Droseraceae
–	*Hypolaena exsulca*	Restionaceae
–	*Lagenophora* sp.	Asteraceae
–	*Lepidosperma costale*	Cyperaceae
–	*Lepidosperma squamatum*	Cyperaceae
–	*Lomandra nigricans*	Dasypogonaceae

Species Common name	Scientific name	Family
–	*Lomandra preissii*	Dasypogonaceae
Silky Mat Rush	*Lomandra sericea*	Dasypogonaceae
–	*Lyginia barbata*	Restionaceae
–	*Meeboldina coangustata*	Restionaceae
Purple Flag	*Patersonia occidentalis*	Iridaceae
Tapeworm Plant	*Platysace compressa*	Apiaceae
Pink Fountain Trigger Plant	*Stylidium brunonianum*	Stylidiaceae
Reed Trigger Plant	*Stylidium junceum*	Stylidiaceae
Common Butterly Trigger Plant	*Stylidium piliferum*	Stylidiaceae
Matted Trigger Plant	*Stylidium repens*	Stylidiaceae
Cow Kicks	*Stylidium schoenoides*	Stylidiaceae
Violet Trigger Plant	*Stylidium violaceum*	Stylidiaceae
Many-flowered Fringed Lily	*Thysanotus multiflorus*	Anthericaceae
–	*Thysanotus patersonii*	Anthericaceae
Yellow Autumn Lily	*Tricoryne elatior*	Anthericaceae
Xanthosia huegelii	Apiaceae	
Annual		
Pimpernel Sundew	*Drosera glanduligera*	Droseraceae
Pity Sword Sedge	*Lepidosperma longitudinale*	Cyperaceae
Orchids		
Dancing Orchid	*Caladenia discoidea*	Orchidaceae
Cowslip Orchid	*Caladenia flava*	Orchidaceae
Pink Fairy Orchid	*Caladenia latifolia*	Orchidaceae
Hill's White Spider Orchid	*Caladenia longicauda* subsp. *clivicola*	Orchidaceae
Common Spider Orchid	*Caladenia vulgata*	Orchidaceae
Common Donkey Orchid	*Diuris corymbosa*	Orchidaceae
Purple Enamel Orchid	*Elythranthera brunonis*	Orchidaceae
White Bunny Orchid	*Eriochilus dilatatus*	Orchidaceae
Hare Orchid	*Leporella fimbriata*	Orchidaceae
Common Mignonette Orchid	*Microtis media*	Orchidaceae
Bird Orchid	*Pterostylis barbata*	Orchidaceae
Jug Orchid	*Pterostylis recurva*	Orchidaceae
Banded Greenhood	*Pterostylis vittata*	Orchidaceae
Limestone Snail Orchid	*Pterostylis* aff *nana*	Orchidaceae
Blue Lady Orchid	*Thelymitra crinita*	Orchidaceae
Plain Sun Orchid	*Thelymitra sp Plain sun orchid*	Orchidaceae
Cycad		
Zamia	*Macrozamia riedlei*	Zamiaceae

Species Common name	Scientific name	Family
Grass Tree		
–	*Xanthorrhoea brunonis*	Xanthorrhoeaceae
Non-native species		
Herbs		
Annual		
Blowfly Grass	*Briza maxima*	Poaceae
Orchids		
South African Orchid	*Disa bracteata*	Orchidaceae

PART IV: A NEW METHOD FOR REMNANT VEGETATION EVALUATION, HEALTH ASSESSMENT AND INDICATORS FOR RESTORATION

INTRODUCTION

The awareness of landscape degradation has prompted identification, evaluation and restoration of remaining patches of native vegetation. In Western Australia, this is of particular importance in the wheatbelt, where less than 3% of some woodland types remain (Yates and Hobbs 1997, Hobbs 1999). Many tools, tables or guidelines of assessment have now been developed to assist in evaluating the status of remaining patches of remnant vegetation (Anon, Hobbs and Yates 1997, Bushcare 2001, Safstrom 1995). The very nature of these evaluations depends largely on subjective assessments, which reflect the assessor's knowledge of both ecosystem elements and details of the particular remnant subject to assessment. Too frequently, the availability of time and personnel are limited when, for example, all nature reserves within an entire shire need assessment. These limitations often necessitate cursory judgements in terms of the status of the vegetation. However, effective restoration demands more than a cursory knowledge of the status of vegetation of a remnant.

Some assessments provide no more than a general indication of the status of vegetation, and the terminology often refers only to broad headings. For example, vegetation priority classification is judged as Highest, Very High, High and Medium (Remnant Protection Priority Classification : Hussey and Wallace 1993), or vegetation condition as Pristine, Excellent, Very Good, Good, Degraded, Completely Degraded (Vegetation Condition Scale : Keighery 1994). Other assessments provide, for example, detailed information on a subset of ecosystem elements (Tongway and Hindley 1995). However, detailed results on one component of the landscape cannot stand alone as a means of assessment of ecosystem health.

While all current evaluations provide valuable information, it appears that no single evaluation examined is sufficiently broad enough to assess a remnant within the landscape, in addition to assessing the finer details which make up the ecosystem of that particular remnant. Furthermore, many forms of assessment (as referred to above) do not include the dynamic element or biotic component, without which ecosystem function is not complete. This highlights the difference between generalized classification of vegetation and the assessment of ecosystem health or, specifically, the presence and well being of all functional elements within the ecosystem, including the status of the vegetation.

The ecosystem health of two reserves of remnant vegetation, of contrasting location, ecology and management, were monitored intensely for two years (see Parts I, II and III). Based on the outcomes of this monitoring and a critical evaluation of other assessment

techniques, a rigorous process of community trials, evaluation and refinement followed to produce a table that gives the opportunity to conduct a rapid, simple, yet meaningful assessment of the health of a remnant, both within the landscape and with reference to component elements within the system. The table has been planned for use primarily in woodlands, but may be adapted for use in other types of vegetation. It has been designed to be used either on its own, or to complement other evaluations which include more detailed assessments with particular reference to vegetation and surrounding landscape. The table may be used as a 'one-off' or for repeated assessments. The more assessments made, incorporating seasonal and annual changes, the more robust the information. Nevertheless, the table has been designed so that the most important functional elements within the ecosystem are represented and a reasonably comprehensive assessment can be made based on a single session of observations, given that these are scored relatively reliably. A degree of local knowledge is highly recommended. The assessment by and involvement of members of the local community engenders an ethos of stewardship towards the land.

Given the subjectivity of vegetation assessment, this table provides a degree of standardization of assessment by the same, or different, individuals across vast areas of differing vegetation communities.

The results of the table may be used to interpret indicators of areas requiring restoration. For example, the absence of small passerine birds may be an indication of the absence of a sufficient layer of shrubs, or the abundance of weeds may be preventing the establishment of a native herbaceous layer. Therefore, restoration initiatives would be directed towards the establishment of a more functional shrub layer and the long-term removal of weeds. The table may, therefore, become a prerequisite within applications for funding for restorative initiatives. However, it must be noted, that for both human and ecosystem health, in many cases, it is far more cost effective to implement preventive measures than to attempt cures after system damage occurs (Calver 2000).

It has been recognized that more intensive monitoring should be undertaken in selected remnants to improve the knowledge and understanding of restoration and remnant rehabilitation processes (Strawbridge 1999). This table attempts to provide a means of fulfilling this objective.

METHODOLOGY

Initially, a preliminary table of assessment was created which detailed elements associated with the vigour, organization and resilience of ecosystem health, as outlined in Part I. Following intensive monitoring of the two reserves for two years, as detailed in Part III the table was modified according to the results of this monitoring. User-friendly terminology was selected and an extensive process of trials conducted by individuals, community groups and land-carers followed.

The table is, in the main, self-explanatory. A user may make minor alterations to standardize the methodology to whatever is practicable

for particular situations. For the first-time user, the following comments may help standardize the procedure. In addition, Appendices 1 and 2 provide examples of the assessment of the two study reserves.

GENERAL INSTRUCTIONS

A comprehensive evaluation of the health of a remnant will include seasonal and annual assessments. If this is not possible, assessments should be carried out at the most biologically productive time of the year for that site. If this is not possible, reliable anecdotal information is extremely valuable and should be included.

If it is not possible to score an item, do not enter zero. Rather, subtract the (largest) score for that item from the total on that page and from the Overall Health on Page 5. For example, if time limitation prevents a thorough nest search, subtract 3 (open country birds) or 6 (open country birds and nectarivores/insectivores) from 36 and from 113. Similarly, if it is impractical to germinate seed from the seed bank, subtract two from 42, and from 113.

If, for example, the dominant vegetation is heath, all scores applicable to trees (16) are subtracted from 35 and from 113. See Appendices 1 and 2 for examples.

SPECIFIC INSTRUCTIONS

Page 1:

Photographs taken seasonally or annually from the same position provide a visual record of any changes in the area. However, caution must be exercised as photo points can be misleading where species cover is improving but not species recruitment (Strawbridge 1999).

Page 2:

Evaluation of the vegetative growth and recruitment must incorporate all habitats within the site being assessed.

Caution must be exercised when scoring vegetation with particular characteristics. For example, woodlands with characteristically sparse, albeit healthy, understorey must be scored appropriately.

Page 3:

If mammals are not obvious on the site, a concerted effort is recommended to search for evidence of their presence. This includes searching for tracks, scats, diggings and scratchings. Preferentially, an area of soft sand (3 m x 1 m) should be cleared of all vegetation and left at least overnight for evidence (tracks, prints) of mammalian activity.

It is recommended that a minimum of 20 minutes be devoted to bird observation, preferably early in the morning.

A minimum of 20 minutes should be spent searching for invertebrates, reptiles and frogs.

Page 4:

Seed assessment

Canopy store

Collect seed from selected species of plants. Place seed on a layer of clean (pasteurised) soil in clean, labelled punnets or trays. Cover lightly with clean soil. Water as required and monitor germination. If the above is not possible, cut the seeds to determine if

Goomalling reserve showing long unburnt woodland. Photo June 2000.

Volunteers conducting bird survey at Goomalling reserve. Photo June 2000.

Volunteers inspecting hollow logs at Goomalling reserve for signs of fauna. Photo August 2000.

Franklandia reserve showing mixed shrubland. Photo February 2001.

Volunteer recording vegetation at Goomalling reserve. Photo November 1999.

Volunteer conducting insect survey at Goomalling reserve. Photo June 2000.

healthy endosperm is present (= present, ? viable).

Seed bank

Remove the biomass litter layer, without disturbing the soil, from up to ten sites in different areas of the study site. Collect soil cores measuring 20 cm x 20 cm x 2 cm (see Saffer *et al.* 2002) from these cleared areas. Without mixing the samples, place soils up to 1 cm in depth in clean, labelled punnets or trays. Water as required and monitor germination. If the above is not possible, examine the samples carefully for seed (= present, ? viable).

Once the trays or punnets have been prepared for canopy and/or soil seed, it is preferable, if possible, to expose the trays to smoke for up to one hour or to water with smoke water to enhance germination (see Dixon *et al.* 1995).

GLOSSARY

annual	plants that complete their life cycle in a year
bryophyte	mosses and worts
fungi	including lichens
insectivore	insect-eating birds
invertebrate	insects, spiders *etc.*
macropod	marsupials including kangaroos, wallabies *etc.*
nectarivore	nectar-eating birds
open country bird species	ravens, crows, magpies, parrots *etc.*
perennial	plants that persists for several years
photopoint	annual or seasonal photogragh(s) taken from a fixed, marked position

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Remnant vegetation evaluation : health assessment

Examiner: Season:

Date end time: Duration of assessment:

Patch identification: Photograph(s) from photopoint(s):

Nearest town (include distance and direction): GPS:

Annual rainfall (rain days): Position in landscape:

Shape, perimeter/eree ratio: Size:

Description of dominant vegetation:

Soil type: Evidence, extent end degree of erosion:

History of grazing: Fencing:

History of fire:

Water - prasence, (periodicity) or proximity (including size of water body):

Threatened species or communities (flora or fauna):

Conservation status:

Nearest remnant (size and distance):

Corridors; attachment/distance and width:

Surrounding landscape:

History - cultural:
neturel:

Overall Health:

Vegetative growth and recruitment (Page 2):

Mammals, birds, invertebrates and others (Page 3):

Salinity, weeds, use and seeds (Page 4):

Conclusion:

Vegetative growth and recruitment

	None = 0	Few = 1-2	Present = 3-4
Presence of trees			

	None = 0	Old = 1	Saplings = 2	Adult = 3-4
Age of predominant trees				

	Dead = 0	Unwell-dying = 0-1	Unwell-regenerating = 2	Healthy = 3-4
Health of (predominant) trees				

	None = 0	Few = 1-2	Present = 3-4
(Potential) hollows			

	Absent 0	Minimal 1	Moderate 2	Abundant 3
Ground cover:				
annuals				
perennials				
shrubs				
seedlings				
biomass litter				
fungi, lichen and bryophytes				

	Bad 0	Poor 1-9	Fair 10-20	Good 21-24	Excellent 25-35
Sub-total					

Diversity / biotic components

Native

	Over abundance 0	Absent 0	Occasional 1	Present 2	Abundant 3
Mammals:					
large (macropods)					
small (possums, echidna *etc* .)					
Birds:					
Open country species					
present/foraging					
nesting					
Nectarivores, insectivores					
present/foraging					
nesting					
Invertebrates:					
Frogs, lizards and snakes					

Introduced

	Dominant 0	Present 1	Occasional 2	Absent 3
Mammals:				
large (cattle, sheep, horses, donkeys, goats, pigs *etc* .)				
medium (fox, dog, cat)				
small (rabbit)				
Invertebrates:				
including feral bee				

Sub-total

Bad 0	Poor 1-8	Fair 9-15	Good 16-24	Excellent 25-36

Disturbance and degradation

	0	1	2	3
	Present	Present - adjacent	Present - distant	Absent
Evidence of salinity				
	Abundant	Moderate	Minimal	Absent
Non-native vegetation				
trees and shrubs				
weeds				
Litter				
large (soil dumping, old fencing *etc.*)				
small (human refuse)				
Tracks and scats				
human (including vehicles, trail bikes)				
fox				
rabbit				
cat				
Diggings:				
fox				
rabbit				

Resilience

	Nil = 0 0	Present, ? Viable 1	Present, germinable 2
Seed assessment, including viability and germinability			
canopy store			
seed bank			

Sub-total	Bad 0	Poor 1-10	Fair 11-22	Good 23-30	Excellent 31-42

Bad	Poor	Fair	Good	Excellent

Vegetative growth and recruitment (Page 2)

0	1-9	10-20	21-24	25-35

Mammals, birds, invertebrates and others (Page 3)

0	1-8	9-15	16-24	25-36

Salinity, weeds, use and seeds (Page 4)

0	1-10	11-22	23-30	31-42

Comments

Other observations of note:

Overall Health:

Bad	Poor	Fair	Good	Excellent
0	1-27	30-57	60-78	81-113

Restoration Indicators:

Remnant vegetation evaluation : health assessment

Examiner: VMS

Season: spring

Dete end time: October 2001

Duration of essessment: 20 minutes each site

Petch Identification: Cemetery reserve

Photogreph(s) from photopoint(s): yes

Neerest town (include distence end direction): 1 km east of Goomelling

GPS: 31°16'S, 116°47'E

Annuel rainfell (rain deye): 370 mm (83)

Position in landscape: mid landscape

Shape, perimeter/erea retio: oval to diemond

Size: 120 ha

Description of dominent vegetation: eucelypt woodlend with open understorey

Evidence, extent and degree of erosion: nil obvious

Soil type: loamy

History of grazing: nil for et least 80 yeers

Fencing: nil

History of fire: nil for at leest 80 yeers

Weter - presence, (periodicity) or proximity (including size of weter body):
Lake Walyurmouring (Oak Park) 15 km N-E

Threetened species or communities (flore or feune): nil known

Conservation stetus: Class C ; travellers and stock

Nearest remnent (size end distance):
disturbed woodland (crown lend) on W boundary

Surrounding landscape: farmland N and N-E, Dowerin road to E, disturbed woodland and disused rifle range S and W

Corridore: ettachment/distance end width: nil

History - culturel: the reserve and surrounding country wes used by Nyungers for hunting. Now used infrequently by local Nyungers for hunting.

natural: unmenaged woodland with hietory of dumping, timber collecting and indiscriminete vehicluer use.

Overall Health:

Vegetative growth and recruitment (Page 2):	Excellent. 26 out of 35
Mammals, birds, invertebrates and others (Page 3):	Good. 23 out of 36
Salinity, weeds, use and seeds (Page 4):	Fair. 18 out of 40

Conclusion:

The reserve appears to be in relatively good condition (67 / 111)
Main issues ere:
- weed control
- elimination of farel animals and bees
- educete public

Vegetative growth and recruitment

	none = 0	few = 1-2	present = 3-4
Presence of trees			4

	none = 0	old = 1	saplings = 2	adult = 3-4
Age of predominant trees				4

	dead = 0	unwell-dying = 0-1	Unwell-regenerating = 2	healthy = 3-4
Health of (predominant) trees				4

	none = 0	few = 1-2	present = 3-4
(Potential) hollows			4

	Absent =0	Minimal =1	Moderate =2	Abundant =3
Ground cover:				
annuals				4
perennials		1		
shrubs			2	
seedlings		1		
biomass litter		1		
fungi, lichen and bryophytes		1		

Sub-total	Bad 0	Poor 1-9	Fair 10-20	Good 21-24	Excellent 25-35
					26

Diversity / biotic components

	Over abundance 0	Absent 0	Occasional 1	Present 2	Abundant 3
Native					
Mammals:					
large (macropods)				2	
small (possums, echidna *etc*)				2	
Birds:					
Open country species					
present/foraging					3
nesting			1		
Nectarivores, insectivores					
present/foraging				2	
nesting			1		
Invertebrates:					
Native					3
Frogs, lizards and snakes			1		

	Dominant 0	Present 1	Occasional 2	Absent 3
Introduced				
Mammals:				
Introduced				
large (cattle, sheep, horses, donkeys, goats, pigs *etc*)				3
medium (fox, dog, cat)		1		
small (rabbit)			2	
Invertebrates:				
Introduced (including feral bee)			2	

Sub-total	Bad 0	Poor 1-8	Fair 9-15	Good 16-24	Excellent 25-36
				23	

Disturbance and degradation

	0	1	2	3
	present	present - adjacent	present - distant	Absent
Evidence of salinity				3
	Abundant	Moderate	Minimal	Absent
Non-native vegetation				
Trees and shrubs				3
Weeds		1		
Litter				
Large (soil dumping, old fencing *etc.*)		1		
Small (human refuse)			2	
Tracks and scats				
human (including vehicular)		1		
fox		1		
rabbit			1	
cat			1	
Diggings:				
fox			1	
rabbit			1	

Resilience

Seed assessment, including viability and germinability	nil = 0	present, ? viable =1	present, germinable =2
canopy store			
seed bank			2

Sub-total	Bad 0	Poor 1-10	Fair 11-22	Good 23-30	Excellent 31-40
			18		

	Bad	Poor	Fair	Good	Excellent
Vegetative growth and recruitment (Page 2)	0	1-9	10-20	21-24	25-35
					26
Mammals, birds, Invertebrates and others (Page 3)	0	1-8	9-15	16-24	25-36
				23	
Salinity, weeds, use and seeds (Page 4)	0	1-10	11-22	23-30	31-40
			18		

Comments

Other observations of note:

Weeds are predominantly on the edges.

Regenerative potential is present and the reserve appears sustainable in the event of a major perturbation such as fire.

Farmers on adjacent properties are keen to control feral animals.

Overall Health:

Bad	Poor	Fair	Good	Excellent
0	1-27	30-57	60-78	81-111
			67	

Restoration Indicators:

Remove fox, dog, cat and rabbit.

Remove feral bee hive(s).

Control weeds. Eradicate Paterson's curse (*Echium plantagineum*) which has just started appearing alongside to the railway line.

Seal off non-essential tracks

Educate public re unlawful dumping, timber collecting, track usage.

Examiner: VMS Season: spring

Date and time: October 2001 Duretion of essessment: 20 minutes each eite

Patch identificetion: Franklandia Photograph(s) from photopoint(s): yee

Nearest town (include distance and direction): 14 km S, S-E Bunbury
GPS: 33°25'S, 115°42'E

Annual rainfall (rein deys): 900 mm (122) Position in lendscape: mid to lower landecape

Shape, perimeter/aree retio: rectangular Size: 19.56 ha

Description of dominent vegetation: Jarrah/bankeia woodland

Evidence, extent end degree of erosion: nil obvious Soil type: sandy

History of grazing: Intrequent, ehort incurelone of cattle prior to 1995
Fencing: yee

History of fire: emall contained tiree reported in 1981, 1995 and 1996

Water - presence, (periodicity) or proximity (including size of water body):
Preeton River <200 m E

Threatened species or communities (flore or feuna): *Franklandia triaristrata* (priority sp.)
Acacia flagelliformis and *A. semitrullata* (geographically restricted)

Conservation status: Claee A : Parklands

Neerest remnant (size and distance): smsll remnsnt (crown land) scross South-Western highway.

Surrounding lendscape: N - not cleared, cattle: W - cleared, regenerating, S - cleared
and stocked with cettle, E South-Western highway

Corridors: ettechment/distence end width: nil

History - cultural: nil of signiticance
netural: Reserve since 1886. Menaged by CALM, DOLA end Bunbury
Natursilsts Club since 1995.

Overall Health:

Vegetative growth and recruitment (Page 2):	Excellent. 27 out of 35
Mammals, birds, invertebrates and others (Page 3):	Good. 18 out of 36
Salinity, weeds, use and seeds (Page 4):	Fair. 21 out of 40

Conclusion:

The reserve sppears to be in relatively good condition (66 / 111)
Main issues ere:
ensure fencing remains intact to safeguard egainst cattle entering
monitor damage by kangaroos snd effect s solution
eradicete rebbits and foxee

Vegetative growth and recruitment

	none = 0	few = 1-2	present = 3-4
Presence of trees			4

	none = 0	old = 1	saplings = 2	adult = 3-4
Age of predominant trees				4

	dead = 0	unwell-dying = 0-1	Unwell-regenerating = 2	healthy = 3-4
Health of (predominant) trees				3

	none = 0	few = 1-2	present = 3-4
(Potential) hollows			3

	Absent =0	Minimal =1	Moderate =2	Abundant =3
Ground cover:				
annuals			2	
perennials				3
shrubs				3
seedlings		1		
biomass litter			2	
fungi, lichen and bryophytes			2	

Sub-total	Bad	Poor	Fair	Good	Excellent
	0	1-9	10-20	21-24	25-35
					27

Diversity / biotic components

	Over abundance 0	Absent 0	Occasional 1	Present 2	Abundant 3
Native					
Mammals:					
large (macropods)	0				
small (possums, echidna *etc*)		0			
Birds:					
Open country species					
present/foraging				2	
nesting		0			
Nectarivores, insectivores					
present/foraging					3
nesting				2	
Invertebrates:					
Native				2	
Frogs, lizards and snakes					3

	Dominant 0	Present 1	Occasional 2	Absent 3
Introduced				
Mammals:				
Introduced				
large (cattle, sheep, horses, donkeys, goats, pigs *etc*)				3
medium (fox, dog, cat)		1		
small (rabbit)		1		
Invertebrates:				
Introduced (including feral bee)		1		

Sub-total	Bad 0	Poor 1-8	Fair 9-15	Good 16-24	Excellent 25-36
				18	

Disturbance and degradation

	0	1	2	3
	present	present - adjacent	present - distant	Absent
Evidence of salinity				3
	Abundant	Moderate	Minimal	Absent
Non-native vegetation				
Trees and shrubs				3
Weeds			2	
Litter				
Large (soil dumping, old fencing *etc.*)				3
Small (human refuse)				3
Tracks and scats				
human (including vehicular)			2	
fox		1		
rabbit	0			
cat			1	
Diggings:				
fox			1	
rabbit	0			

Resilience

Seed assessment, including viability and germinability	nil = 0	present, ? viable =1	present, germinable =2
canopy store			
seed bank			2

Sub-total	Bad	Poor	Fair	Good	Excellent
	0	1-10	11-22	23-30	31-40
			21		

	Bad	Poor	Fair	Good	Excellent
Vegetative growth and recruitment (Page 2)					
	0	1-9	10-20	21-24	25-35
					27
Mammals, birds, Invertebrates and others (Page 3)					
	0	1-8	9-15	16-24	25-36
				18	
Salinity, weeds, use and seeds (Page 4)					
	0	1-10	11-22	23-30	31-40
			21		

Comments

Other observations of note:

Regenerative potential is present and the reserve appears sustainable in the event of a major perturbation such as fire.

May be some dieback on N-E aspect.

Rabbit warrens where present are extensive and need treatment.

Kangaroos damaging fencing. Farmer to south wants them culled.

Kangaroos foraging on young *Franklandia triaristrata* leaves. Chicken wire fencing *in situ* around one group of plants.

Overall Health:

Bad	Poor	Fair	Good	Excellent
0	1-27	30-57	60-78	81-111
			66	

Restoration Indicators:

None at present

Regeneration following 1995 cleanup present. Tracks growing over.